THE

ACTION OF MEDICINES

IN

THE SYSTEM;

OR,

"ON THE MODE IN WHICH THERAPEUTIC AGENTS INTRODUCED INTO THE STOMACH PRODUCE THEIR PECULIAR EFFECTS ON THE ANIMAL ECONOMY."

Being the Prize Essay to which the Medical Society of London awarded the Fothergillian Gold Medal for mdccclii.

BY

FREDERICK WILLIAM HEADLAND, M.D., B.A., F.L.S.,

LICENTIATE OF THE ROYAL COLLEGE OF PHYSICIANS, ETC., ETC.

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TO

THE PRESIDENT, OFFICERS, AND FELLOWS

OF THE

MEDICAL SOCIETY OF LONDON,

This Essay

IS RESPECTFULLY INSCRIBED, BY THEIR VERY OBLIGED

FRIEND AND SERVANT,

THE AUTHOR.

PREFACE

TO THE THIRD EDITION.

The Author wishes to express his regret for the delay that has taken place in the publication of this Edition. It has been caused by his desire that nothing should be wanting which could ensure the completeness of the Essay.

In occupying an humble, but not unacknowledged place, among many earnest labourers in a department of medical science that till lately was little explored, he has attained, for the present, the height of his ambition.

In this Third Edition some matters are noticed which were not before included, and certain topics, of particular interest to the Author, and, he trusts, to his readers also, are discussed more fully than before.

37, *Margaret Street, Cavendish Square.*
March, 1859.

PREFACE

TO THE SECOND EDITION.

The First Edition of this Essay having been for some time out of print, the Author has been encouraged to hope that a second issue may meet with a favourable reception. He has been at some pains to make such additions to the present volume as seemed to be necessitated by the rapid advance of therapeutic science, at the same time that he has felt the necessity of not increasing its bulk to an inconvenient extent. The first and second chapters have been left unaltered, but some new articles will be found scattered through the third and fourth chapters, and some additional observations and experiments recorded in the same.

The Author has derived much instruction from a perusal of the various reviews of his Essay, in English and American periodicals. He is especially indebted to Dr. Maclagan, of Edinburgh, for his able and interesting articles in the Monthly

Journal of Medicine. And to Professor Albers, of Bonn, the author of a recent work on the Action of Medicines, he is obliged for the impartial consideration accorded to certain views in which he is still at variance with some other German therapeutists.

April, 1855.

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CHAPTER I.

INTRODUCTORY REMARKS.

WHEN commencing this Essay on the Action of Medicines, I must confess that I felt a degree of discomfort when I considered the magnitude of the task before me. Many a volume has been written to elucidate the operations of single medicines, and when the variety and complexity of such an operation is considered, the space devoted to its consideration will hardly seem too great. Thus it is not to be wondered at, that when pausing on the threshold of my undertaking, I should have been sensible of the many difficulties with which such an inquiry was surrounded.

In this introductory chapter it shall be my aim in the first place to set forth briefly the great importance and extent of the subject, showing that it is an essential requisite in the advance and perfection of medical science. Next, I must insist on the advantage of correctness and clearness of language and argument in the treatment of such topics as this, and show in what manner I propose myself to attain to it. And in the third place, I must shortly explain the scheme or arrangement which will be followed in this Essay. If the preliminary remarks contained in this chapter are not first considered and clearly apprehended, I fear that I may be but imperfectly understood in what I shall have to say hereafter.

There have been, more or less, in all ages, two systems or schools of medical treatment, of which the one prevails among ignorant men, and in rude states of society, but the other requires a higher degree of enlightenment. These are the Empirical and the Rational systems. The first is founded on simple induction. By accident or by experience it is found that a certain medicine is of use in the treatment of a certain disorder; it is henceforth administered in that disorder; and on a number of such separate data an empirical system is constructed. It naturally requires for its elaboration a comparatively small degree of knowledge.

Now this observation of facts is indispensable as a beginning, but something more is required. We must not be satisfied with taking them separately, but we must proceed to compare together a large number of facts, and draw inferences from this comparison. And our plan of treatment will become rational, when on the one hand, from an accurate knowledge of the symptoms of diseases, we are better enabled to meet each by its appropriate remedy; and on the other hand, from some acquaintance with the general action of a medicine, we are fitted to wield it with more skill and effect, and to apply it even in cases where it has not yet been proved beneficial.* Thus, for the proper perfection of medicine as a rational science, two things are in the main needed; the first is a right understanding of the causes and symptoms of disease; the second, a correct knowledge of the action of medicines. Should our acquaintance with these two subjects be complete, we should then be able to do all that man could by any possibility effect in the alleviation of human suffering. This sub-

* "If experience is not directed by theory, it is blind."—*Bacon.*

lime problem is already being unravelled at one end. Diagnosis and Nosology are making rapid strides; and perhaps we shall soon know what we have to cure. But at the other end our medical system is in a less satisfactory condition; and though some impatient men have essayed, as it were, to cut the Gordian knot, and have declared boldly on subjects of which they are ignorant, yet it must be confessed, that in the understanding of the action of medicines, and of their agency in the cure of diseases, we do not so much excel our ancestors. While other sciences are moving, and other inquiries progressing fast, this subject, so momentous in its applications, has, in spite of the earnest labours of a few talented investigators, made after all but small progress. Let but those who feel this want bestir themselves to remove it, and it will soon be done. Those doubts and difficulties, which are now slowly clearing away before the efforts of a few, will then be finally dispelled by the united energies of all; and instead of our present indecision and uncertainty on many points, we shall find ourselves eminently qualified to wage the conflict with disease, being skilled in that science whose name bespeaks its peculiar importance, the science of *Therapeutics*.*

The subject which forms the text of this Essay comprises this problem:—"On the mode in which Therapeutic Agents introduced into the stomach produce their peculiar effects on the Animal Economy." In this is comprehended an inquiry of very great extent; and one difficulty with which I am beset is that I scarcely know how to compress what I have to say on the action of medicines into the compass required. It will be granted that it is an important subject; it is also a difficult one. This difficulty depends mainly on the variety and com-

* *Therapeutics* must be understood to embrace all that relates to the application of remedies to the cure of disease. The Science must be distinguished from the Practice of Therapeutics. The latter *may be* empirical, or rely upon experience only; but the science must have for its very foundation some knowledge of the *modus operandi* of medicines.

plexity of the proof required to establish any one point with absolute certainty.* A long time ago, when men knew and understood less than they do now, it was fancied that the action and choice of medicines was a thing of the utmost simplicity; that it was comparatively an easy matter to fix at once upon that remedy required most in any particular case.† But the light of science, which in this day burns more brightly, at the same time that it displays all objects with greater distinctness, discloses to us also many dim vast tracts in the distance, of which nothing had been seen or imagined before. In this as in other things, the more we know, the more we discover our real ignorance. It is wrong, then, to treat dogmatically of matters that we cannot comprehend; and when perfectly in the dark as to the operation of a medicine, we should rest content with declaring the result of that operation. This by itself will be of great use to us.‡

I am induced to lay stress on the difficulties surrounding an inquiry into the *modus operandi* of medicines, because it will be some excuse for the manifest insufficiency of the sketch which I am about to draw. For this, too, I may find a further apology in the fallacies and mistakes, both of reasoning and statement, of which previous writers have been guilty. These are best shown by their discrepancies. On no question, per-

* "In reasoning as to the probable effects of particular remedies on the human body, the conditions and circumstances of the latter are so various in different cases, and the number of concomitants which have to be considered in addition to the more obvious facts and symptoms, is so great, that the utmost exertion of human sagacity, founded upon the largest induction of particulars which any one mind is capable of embracing and retaining, can do no more than approximate to that real evidence of which the case seems by its proper nature to be susceptible."—*Glassford's Principles of Evidence.*

† Dr. A. Pitcairn, in 1704, concluded one of his works by saying—"Thus have I succeeded in solving the noble problem, viz. to find a remedy for a given disease. *Jamque opus exegi.*"

‡ "In the meantime it may suffice for the physician to know the effects of a medicine when applied to the body, though he knows not the particular manner whereby it acts."—*Van Swieten's Commentaries on Boerhaave, vol. i. p. 394.*

haps, have scientific men differed more than on the theory of the action of medicines. Either facts essentially opposed and incompatible have been adduced by the disagreeing parties; or, which is nearly as common, the same fact has received two distinct and opposite interpretations. Many hypotheses, when tested, are seen to be grounded on bare assertions, and to be destitute of logical proof; many others are attempted to be established on ill-sustained analogies. Analogy, in such a case as this, may be used to increase a probability already evidenced; but by itself it is no proof, for we find often that medicines are capable of producing the same result in very dissimilar ways.

How then are we to arrive at the truth? The best and surest way is to be extremely careful in the means which we employ in its discovery.

It is, I think, impossible to overrate the importance of *exact precision of language and thought* in scientific details, and in the deduction of conclusions from them.* A subject so interesting as this requires to be treated in a logical way. Facts, when ascertained, should be ranged together and compared, and exact inferences made, without ever straining a point. And when we are inclined to hazard a theory that is barely supported, we should take care to state it as a theory, and not to bring it forward as a truth. It has not been an uncommon habit among scientific authors, who should be of all men the most careful and exact, to confound assertion with fact—to mistake hypothesis for truth. In such illogical and incorrect reasoning is to be found the true source of a multitude of errors.†

* "Every branch of study which can at all claim the character of a science requires two things: 1. A correct ascertainment of the data from which we are to reason; and 2. Correctness in the process of deducing conclusions from them."—*Whately's Elements of Logic.*

† "In the writings of the present day, the premises are commonly sound, but the conclusions false."—*S. T. Coleridge.*

Being sensible of this danger, I have endeavoured to keep it in view in the arrangement of this Essay. In order to obtain, if possible, this clearness and precision, or, at all events, to be better understood, I have arranged the heads of my ideas on the action of medicines in a number of distinct propositions, the scope of which will be presently described. I shall attempt to prove each of them separately, as if it were a theorem in geometry, sometimes dividing it first into a number of minor propositions, which, taken together, imply the original one, and will have to be severally discussed.

The great use of such an arrangement is its distinctness; so that it may in any case be easily seen whether a proposition has been established, or whether I have failed to prove it. These propositions are the foundation of the Essay; and upon them has been erected a superstructure of more or less logical consistency. In them has been stated about as much of the general principles by which medicines operate as seems to me to be capable of distinct proof; *i. e.* which may be regarded with that kind of certainty which we generally expect to attain to in scientific matters. So far, then, I have kept myself in a straight road, between two walls, diverging neither to the right nor to the left to gratify my inclination; it being, as I have said, a most obvious duty to guard against stating that for fact which is at the best uncertain. But having gone so far, I have in several instances indulged in speculations and hypotheses on certain matters, taking care to state that such explanations are only probable, and very far from determined. But it is often our duty to inquire into uncertain things; and those who do so, who officiate, in however humble a capacity, as the pioneers of knowledge, have to hazard many conjectures before they arrive at the truth. In striving after truth, we must investigate many an unknown path, and try at many a door where we have not before entered. Thus, when in some cases I have perceived before me a line of thought stretching onwards, and seeming to lead somewhere in the direction of truth, I have not, as it were, shunned it, or turned aside to tread only in more certain paths, but I have thought it my duty to follow it up, and to investigate it thoroughly, to see if by any means it might not help me on my way to that desired haven. These theories are the weak points of the Essay, but I must crave indulgence for them on the grounds alleged above. It will be observed that the original propositions are so stated, that the overthrow of any one of these extra hypotheses would not shake them, or in any way invalidate their proof.

I will now sketch out the arrangement which I propose to follow in the consideration of the topics which present themselves to me.

In the next chapter I shall take a brief review of the opinions of other writers on the subject of the action of medicines; knowing, indeed, that in so short a notice I shall be perfectly unable to do them justice, but wishing in some broad points, to draw the line between what is known and what is unknown,—what is ascertained and what is debated,—what is approved and what is condemned. In some cases also I may venture to object to opinions hitherto unquestioned. Now, as the best key to the main opinions of authors on this subject, we have to consider the various classifications of medicines which they have adopted. A classification of remedies pre-supposes a set of theories concerning either their primary action or its general results, and is, in fact, identical with them. The formation of such an arrangement depends on the necessity of considering medicines in groups, each possessed of some common character, in order that their various properties may be simplified, and admit of being compared.

In a classification we do not so much consider the peculiarities of single remedies, as the points in which large numbers agree together. These points of resemblance we generally find to be of the most importance. I have to consider three sets of authors in the second chapter. The first set treat of the general or ultimate effect of a medicine on the system; and classify medicines accordingly. A second set of writers have arranged therapeutical agents according to the organ or part of the body to which their action is especially directed. Neither of these deal with the mode in which medicines act as the basis of classification. But a third set of writers have attempted in various ways to explain the modes of operation of medicines. They have laid down general rules about these operations, and have constructed more or less plausible theories on the subject. Some few have classified remedies on this plan. Now with these theories I am more particularly concerned, as they trench immediately on the subject of this Essay. But they are not many, and it will not take us long to review them.

It is easier to find fault than to teach. After pointing out the shortcomings of some who have preceded me, I find myself necessitated in the third chapter to state my own conclusions as to the *modus operandi* of medicines.

Let us consider, as it were, the history of a remedy, from the beginning to the end of its course. It is already "introduced into the stomach"—we must commence with it there. Now it does not remain there. It cannot act from the surface of the stomach through the medium of the nervous system.

In the *First Proposition* it is affirmed that it must (as a general rule) obtain entry into the fluids of the body—pass, that is, from the intestinal canal into the system at large—before its action can begin. There are four proofs of this. It is shown that when introduced at another part of the body a medicine acts in the same way as when placed in the stomach. It is found by direct experiment that a poison will not act through the medium of nerves only, but that its passage in the blood is required. Thirdly, the course of the circulation is quick enough for the most rapid poison or medicine to pass quite around the body from the veins of the stomach before it begins to operate. The last and most conclusive argument to show that medicines pass out of the stomach into the system is that they have actually been detected by chemists, not only in the blood, but in the secretions formed from the blood. Remedies, then, pass from the stomach into the blood and fluids. How do they do so?

In the *Second Proposition* it is laid down that all those which are soluble in water, or in the secretions of the stomach or intestines, pass through the coats of these organs into the interior of the capillary veins which surround them. It has already been shown that most medicines pass through in some way; we shall now have to learn how they pass, and what special arrangements are made for the passage of substances differing in nature. By the physical process of absorption a liquid may pass through the animal membranes, from the interior of the stomach or intestine to the interior of the small vein which lies close outside it. In examining the laws by which this process is conducted, we shall find that all the requirements are present in these parts, provided only that the substance to be absorbed shall be first in some way dissolved, and reduced to the liquid state. In the stomach there is, in contact with the substance just introduced, a thin watery secretion, containing acid and a matter called pepsin: this is the gastric juice. A large number of medicines are soluble in water. They are dissolved in this fluid. Some others are soluble in dilute acid. These too are dissolved here. Albumen, and matters like it, are reduced to solution by the aid of the pepsin, which is the principle of digestion. But there are some few mineral bodies, and many vegetable substances, as fats and resins, which cannot be thus dissolved by the juice of the stomach. They are soluble, more or less, in a weak alkaline fluid; and such a fluid is the bile, which is poured out into the first portion of the intestine. They too are reduced to solution and absorbed. In this manner it is shown that a very great majority of remedial agents are capable of being reduced to solution, of being absorbed without material change, and of passing thus into the circulation.* Very few are quite insoluble; but some that are dissolved with difficulty may be left partly undissolved in the intestinal canal. What becomes of those that are incapable of being dissolved?

It is asserted in the *Third Proposition* that substances which are thus insoluble cannot pass into the circulation. Arguing from a physical law, we should say at once that it was impossible; but the matter cannot be so lightly dismissed, for a foreign Professor has lately asserted that insoluble matters may and do pass into the circulation. I have made experiments to satisfy myself on the point, and have come to the contrary conclusion.

In the *Fourth Proposition* it is stated that some few substances may act locally, by irritation or otherwise, on the mucous surface of the stomach or intestines. These are not many; they act without being absorbed; and they may not extend into the system at large. In some few cases these local actions may be succeeded by changes in distant parts, on the principle of *Revulsion.*

Having just shown how medicinal substances are absorbed, we have now to suppose that they are in the blood.

It is next maintained in the *Fifth Proposition*, that the medicine, being in the blood, must permeate the mass of the

* There is no doubt that the small veins which ramify outside the coats of the stomach and intestines are capable of taking up any matters in a state of proper solution, even fats when dissolved in alkali. But are medicines ever taken up by the lacteal absorbents? Probably seldom or never; for it seems that these vessels are only engaged after a full meal, and subsequent to the regular formation of chyle. They do not exist in the coat of the stomach, but commence in the small intestine at some distance from the pylorus.

circulation as far as to reach the part on which it tends to act. This it can easily do. The circulating blood will conduct it anywhere, in a very short time. Supposing a medicine has to act on the liver, or on the brain, or on the kidney, it does not influence these organs at a distance, but it passes directly to them in the blood, and then its operation is manifested. This may be called the rule of *local access.* Its proof depends on two things: on the improbability of the medicinal influence being able to reach the part in any other way, as shown in the first proposition; and on the fact of medicinal agents having been actually detected in many cases in the very organs over which they exert a special influence. But are there any exceptions to this? Can a medicine ever produce an effect without actually reaching the part? It seems that there may be two exceptions. In some cases an impression of *pain*, or an impulse causing muscular action may be transmitted along a nerve from one part to another; and in some other few instances the muscle itself, when caused to contract by the influence of a medicine, may cause other muscles near it to contract by sympathy.

Before we inquire into the remedial action of the medicine in the blood, we must consider whether that fluid may not first alter it in some way, so as to hinder or affect its operation. To a certain extent this is possible.

In the *Sixth Proposition*, it is asserted that while in the blood the medicine may undergo change, which change may or may not affect its influence. It will have to be shown that this change may be one of combination, as of an acid with an alkali; of *reconstruction*, when the elements of a body are arranged in a different way, without a material change in its medical properties, as when benzoic is changed into hippuric acid; or of *decomposition*, when a substance is altogether altered or destroyed, as when the vegetable acids are oxidized into carbonic acid.

Having considered these preliminary matters, we shall arrive at the main point. The medicines are now in the blood. We must consider what becomes of them; what they do next; where they go next; and how they operate in the cure of diseases. I have made a classification in which medicines are divided according to my views of their mode of operation. The classes in their subdivisions will serve for references in illustration of what I have to say. For it is not possible to speak of the general operation of medicines without adducing particular instances; nor will time and space always allow me in doing so, to refer to individual medicines.

There are four great groups of medicines, the action of each of which is well marked and distinct. The first class acts in the blood; and as a large number of diseases depend on a fault in that fluid, we may by their means be enabled to remedy that fault. They are the most important of all medicines. They are called Hæmatics, or blood-medicines. They are used chiefly in chronic and constitutional disorders. But a second class of remedies are temporary in their action. They influence the nervous system, exciting it, depressing it, or otherwise altering its tone. They are chiefly useful in the temporary emergencies of acute disorders. They can seldom effect a permanent cure, unless when the contingency in which they are administered is also of a temporary nature. They are called neurotics, or Nerve-medicines. A third set of medicines, less extensive and less important than the others, act upon muscular fibre, which is caused by them to contract. Involuntary muscular fibre exists in the coats of small blood-vessels, and in the ducts of glands. Thus Astringents, as these agents are called, are able, by contracting muscular fibre, and thus diminishing the calibre of these canals, to arrest hemorrhage in one case (when a small vessel is ruptured,) and to prevent the outpouring of a secretion in another case.

The fourth class is of considerable importance. Some medicines have the power of increasing the secretions which are formed from the blood by various glands at different parts of the body. By their aid we may be enabled to eliminate from the blood a morbid material through the glands; or we may do great good by restoring a secretion when unnaturally suppressed. They are called Eliminatives. Like Hæmatics, their influence is more or less permanent. That of Neurotics and Astringents, particularly the former, is transient.

The general mode of action of these four classes of therapeutic agents is laid down in the four remaining propositions, about as far as it seems to me to be capable of a positive definition. Each proposition concerns one of these classes of medicines. All I can do now is to recapitulate the chief affirmations made; as to give any idea of their proof would require me to enter into a number of details which had better be postponed to the third chapter.

In the *Seventh Proposition* it is stated of Hæmatic medicines, that they act while in the blood, over which fluid they exert an influence; and that their effect, whatever it be, is of a more or less permanent character. A line of distinction is drawn between two divisions of this class of blood-medicines. Some of them are natural to the blood; they resemble or coincide with certain substances that exist in that fluid; so that, having entered it, they may remain there, and are not necessarily excreted again. These are useful when the blood is wanting in one or more of its natural constituents. This want causes a disease, and may be supplied by the medicine, which in its way tends to cure the disease. Medicines of this division are called restoratives; for they *restore* what is wanting.

Some other blood-medicines, although they enter the blood are not natural constituents of that vital fluid, and cannot remain there, for they are noxious and foreign to it. They must sooner or later be excreted from it by the glands. They are of use when disease depends on the presence and working in the blood of some morbid material or agency, which material or action they tend to counteract or destroy. They may be called *vital antidotes;* not strictly *specifics*, for they are not always efficacious, on account of variations in the animal poisons, or from the casual operation of disturbing causes. They are applicable in those many disorders which depend, not on the absence of a natural substance, but on the presence of an unnatural agent in the blood. These medicines are called Catalytics, from a Greek word which signifies *to break up* or *to destroy*. Having performed this, their function, they then pass out of the blood.

All this requires to be proved.

In the *Eighth Proposition* it is stated of Neurotics, or nerve-medicines, that they act by passing out of the blood to the nerves, which they influence. This is only to insist on the rule of *local access* already laid down in Prop. V. It is further affirmed that they are transitory in action. They appear to effect molecular changes in nerve-fibre, similar to those by which the phenomena of the senses are produced, and which are by nature transitory in their results. And yet they may be very powerful, even so as to extinguish vital force. Thus, short and unenduring as is the operation of these agents, it may last long enough to cause death, and so a temporary influence produce a permanent result. There are three divisions of Neurotics. The first set are of use when there is a dangerous deficiency of vital action. These are stimulants. They exalt nervous force, either of the whole nervous system, or only of a part of it. They vary very much in power. A second set called Narcotics, first exalt nervous force, and then depress it. They have thus a double action; but they have also a peculiar influence over the functions of the brain, which is different from any possessed by other nerve-medicines. They control the intellectual part of the brain, as distinguished from its organic function; the powers of *mind* more than those of *life*. Some narcotics tend to produce inebriation;

others sleep, others again, delirium. In the third place some neurotics tend simply and primarily to depress nervous force. They may act on the whole nervous system, or on a part of it only. They are often very powerful; and they are of use when, from any cause, some part of the nervous system is over-excited. They are called sedatives. Like other Neurotics, they are used in medicine as temporary agents in temporary emergencies. If a permanent action be required, the remedy must be constantly administered, so that the effect may be kept up by continual repetition.

In the *Ninth Proposition* it is affirmed of Astringent medicines that they act by passing out of the blood to muscular fibre, which by their contact they excite to contraction. They do not so much influence the voluntary fibre of the muscles, which is under the direct control of the nervous system; but they chiefly manifest their action on the involuntary or unstriped muscular fibre, which is not directly controlled by the brain and nerve-centres, and for this reason, more under the operation of external or irritating agents. Meeting this in the coats of the capillary vessels and of the ducts of glands, they are enabled to act as styptics, and as checkers of secretion. The action of Astringents appears to depend on a chemical cause; for we find that all of them possess the power of coagulating albumen.

The *Tenth Proposition* treats of Eliminatives. It is not said simply that these increase the secretions of a gland; or that they stimulate the glands while passing by them in the blood. But it is laid down as a rule that they act by themselves passing out of the blood through the glands, and that while so doing they excite them to the performance of their natural function. They are substances which are unnatural to the blood, and must therefore pass out of it. In so doing they tend to pass by some glands rather than by others; in these secretions they may be detected chemically; and it is on these glands that they have an especial influence. Their uses in treatment are various and manifold.

In these classes are included all medicines that act after entry into the blood. On referring to the classification which precedes this chapter, it will be seen at a glance what groups of medicines are arranged as orders under each class or division.* In the third chapter I shall attempt at some length to prove the propositions which treat of these four classes; and I shall also attempt to explain the nature and mode of action of the orders, or small groups of remedies.

In the fourth chapter some of the more important medicines will be considered separately, either as individually interesting, or as illustrative of general modes of operation previously described.

I may point to some parts of the Essay as being more original than others, although not perhaps for that reason more valuable. For this purpose may be mentioned the consideration of the second and third propositions; the distinction which I have drawn between the two divisions of Blood-medicines; the account given of Tonics in one of these divisions, and of Anti-arthritics in the other; the treatment of the section on Narcotics; the theory of the action of Eliminative medicines; the experiments made on the action of some remedies in particular (Chap. IV.;) etc.

* It may be of some use if I adduce here a characteristic example of each of the great groups of medicines to which I have alluded above:

Class I. *Hæmatics.*

Div. 1. Restoratives. Iron, in Anæmia.
Div. 2. Catalytics. Mercury, in syphilis.

Class II. *Neurotics.*

Div. 1. Stimulants. Ammonia.
Div. 2. Narcotics. Opium.
Div. 3. Sedatives. Hydrocyanic Acid.

Class III. *Astringents.* Tannic Acid.

Class IV. *Eliminatives.* Cantharides, and Croton Oil.

CHAPTER II.

ON SOME OF THE MORE IMPORTANT CLASSIFICATIONS OF MEDICINES, AND OPINIONS OF AUTHORS RESPECTING THEIR ACTIONS.

I HAVE thought it necessary, before stating at length my own conclusions, to refer to some of the more important statements of authors concerning the subject of which I have to treat; because by so doing I may to some extent indicate what points are to be regarded as determined and proved, and what as still unsettled, and point out where I can agree with other writers, and where I am disposed to differ from them.

But should it seem to any reader that a brief and general review of the literature of the subject, comprising an enumeration of many various and often clashing opinions, would be likely to confuse rather than instruct him, I would advise him to pass on to the next chapter, with which the present one is not essentially connected.

The opinions of authors on the general action of medicines are in most cases best ascertained by observing the manner in which they have arranged and classified them, grouping together those which they consider to be alike in their mode of operation.

Differences of opinion respecting individual medicines will be best considered afterwards, when we come to discuss those medicines. We are now to make inquiry as to the action of classes and groups. So that, in examining classifications as a key to the opinions of writers on this matter, we are only concerned with those which are founded in some way on the effects and operations of medicines.

Now there are three different points of view from which the action of a medicine may be regarded. We may ask,— 1. What is the ultimate effect of its action on the system? 2. To what organ or tissue is its action directed? 3. In what way does it operate?

In other words, we may speak of the *result of the action* of a medicine, of the *direction of the action* of a medicine, or of the *mode of operation* of a medicine.

The first of these questions is the simplest, and may be answered from experience. We know that one medicine is a Purgative, because it opens the bowels. We call another an Alterative, because the manifestations of vital action are somewhat different after its use from what they were before. The last question is the most difficult to answer, because it involves the exact mode in which a medicine first behaves itself, so as to bring about its recognised operation.

Though the arrangements and theories of authors have generally taken into account all three of these questions, yet they have usually given greater prominence to one or other of them. And according to this their predominant idea, I will take the liberty of grouping them into three schools, for the sake of convenience; considering, first, some theories and therapeutical arrangements which are based upon the ultimate effect of medicines; secondly, some that depend upon their local tendencies; and thirdly, some others that concern their mode of operation.

Among those who have directed attention to their *ultimate effect*, regarding that as generally sufficient for practical purposes, are included the great majority of those who have classified medicines. Such arrangements are practically useful, as by their means we are enabled easily to select a medicine which shall produce a required result. A classification founded upon *local tendency* is such as hardly to admit of a practical application, for it is too vague. It is said that the action of Mercury is directed to the blood; that of a tonic to the muscular system. It is not said how they operate, or how these parts are affected. The terms employed are too wide and indefinite. Supposing the word *Neurotic* to signify a medicine acting on the nerves; we cannot say that any known medicine may not at some time or in some way act on the nervous system. The same term means a very different thing when found in a classification based on the *mode of operation* of medicines, for then it signifies a medicine acting on the nerves in a certain way which is defined, and it conveys to us an amount of information respecting that medicine and its applicability which we had not otherwise acquired. A classification of this third kind, though difficult of construction, would naturally be of great practical and scientific utility. The precise mode in which groups of medicines operate has first to be discovered and laid down, together with the results of that operation; and it has then to be proved that each remedy included in a class operates in the exact way predicated of that class. None which do not do so can be consistently included in it. Such an arrangement is precise; there may be a great deal of error, but there is very little vagueness about it. Each name and term should contain in itself and in its position an exact description of the general action of the substances included under it. Such an arrangement I have attempted to construct myself, as it is with the mode of operation of medicines that I am particularly concerned. The chief and obvious objection to such a classification consists in the insufficiency or insecurity of the data which we have to guide us. Thus the best and safest way is to select as the bases of primary subdivision those distinctions which admit of being the most readily and firmly established, and not to rest it on a number of uncertain or questionable hypotheses.

I. Opinions concerning the Ultimate Effect of Medicines, and Classifications founded on this.

Most authors have grouped remedies together according to the broad results of their action. They do not make inquiry as to the mode of operation or behaviour of a medicine after passage into the system; nor do they ask whether this action is especially directed to any organ or tissue; but they judge by external evidence of its ultimate effect on the body, and on the powers of life.

There is commonly a tendency to describe all medicines under two heads, as either causing or diminishing vital activity. Dr. Murray indeed confounds these two effects, and adopts an idea on this subject which was originated by Dr. Brown. I shall now represent in an abridged form the classifications adopted severally by Dr. Young, Dr. Duncan, and Dr. Murray.

Dr. Young.

1. Chemical Agents.
    - Caustics, etc.
2. Vital Agents.
    - A. *Supporting strength.*
        - Nutrients.
    - B. *Causing action.*
        - (Partial and transitory.)
            - Stimulants, Irritants, Astringents, Alteratives, Evacuants.
        - (Permanent.)
            - Tonics.
    - C. *Diminishing action or sensation.*
        - (Primarily.)
            - Narcotics, Nauseants, Sedatives, Diaphoretics.
        - (Secondarily.)
            - Exhaurients.
3. Insensible Agents.
    - Specifics.

In the names of these three classes some reference is made to the *modus operandi* of medicines, but the distinctions thus attempted to be drawn are of the slenderest possible description. Among *chemical* agents are included some that are applied externally, and act then on the tissues in obedience to known chemical laws. But how can we affirm that some medicines passing into the stomach may not act chemically? The term *vital* signifies little, and the word *insensible*, applied to the third class, is a confession of absolute ignorance. It does not attach to a medicine any distinctive character to say that we know nothing of its operation. Pursuing the subdivision further, we find that the distinctions are not well maintained. Tonics support strength, as well as cause action; and it can hardly be said that the action of an Alterative, such as Mercury, is partial and transitory. It seems unwise to have made a separate class of Specifics. They are especially associated with Alteratives. Mercury, Iodine and others, would fall under both groups. Of Evacuants it may be observed, that they are also exhaurient, and thus included in two opposed classes; that their action is not always partial and transitory, as, for example, Purgatives may permanently remedy constipation; and that it seems wrong to have separated Diaphoretics from them.

Thus, neither the primary nor the secondary subdivisions of this arrangement can be reasonably maintained in theory, and we must fall back on the ultimate groups, which are based upon common experience. From this failure we may infer that the idea that medicines differ prominently in causing or diminishing vital activity, upon which idea this and many other arrangements are founded, is, in fact, an erroneous one. There is no such universal distinction. A medicine which at one time raises or excites the vital forces, may at another time depress them; it may do one thing with a sick man, the other thing with a healthy man; it may have the one effect when taken for a short time in moderation, the other effect when taken for a long time, or in excess. In fine, the result of the operation of a medicine does not necessarily depend upon this alternative. Although there are undoubtedly some medicines which tend to stimulate the nervous forces, and others which tend to depress them, yet as there are many remedies which may operate well without doing either the one or the other, and whose operation does not depend at all upon this, the distinction cannot be generally applied.

The next arrangement, that of Dr. Duncan, appears, as far as it extends, to be correct in theory. If some additions were made to it, it would be a tolerably perfect classification of this kind. Assuming as a basis the ultimate or practical effect of medicines, we may proceed to divide them into groups in a natural way. Food and liquids are of use in the nutrition of the tissues, and will form the first class. A second set of substances act so as to expel from the body certain humours and secretions. Another class exalt the tone of the nervous system, and through it stimulate the system at large. A fourth set depress the same. And a fifth group do none of these things; but their action results in certain obvious changes in the chemical nature of the secretions.

Dr. Duncan.

Alimenta.

Diluentia, Demulcentia.

Evacuantia.

Diaphoretica, Errhina, Expectorantia,
Cathartica, etc.

Stimulantia.

Topica (irritants, etc.)
Generalia Permanentia.
Generalia Transitoria.

Deprimentia.

Refrigerantia, Narcotica.

Chemica.

Acida, Alkalina.

As far as it extends, this classification seems to be founded on correct data. The smaller divisions are natural. Thus Evacuants are grouped according to the part of the system at which the evacuation is made. General Stimulants are divided into those which are transitory in action, and those whose effect is permanent, as Tonics. Dr. Duncan is concerned only with the ultimate effect, and enters into no theory respecting the action of Tonics. I regard them as medicines acting primarily in the blood, and, applying my terms with a view to the *modus operandi*, I would restrict the term Stimulant to medicines acting on the nerves, whose effect is transitory.

The great fault of this arrangement is the omission of the very important class of Alteratives. We have medicines which increase secretion; medicines which exalt or diminish the vital energy; but where are the remedies which act in the blood? Where, for example, shall we place such medicines as Mercury, Arsenic, and Iodine, which neither act by eliminating, nor by stimulating, nor by depressing, but appear to counteract in the blood the agency of certain morbid poisons? In an arrangement founded on ultimate effect, they should be grouped in a class as Alteratives, as medicines which result in *altering* for the better the condition of the system. Both Dr. Duncan and Dr. Murray seem to have thought that no medicines could act in the fluids but such as have a well-known chemical effect upon them. It cannot be that medicines should be able to affect the nerves, and to influence the glands, in divers ways, but that none should exert any action upon the blood, a most susceptible and changeable fluid, the medium of nutrition, the source of all the tissues, the "*fons et origo*" of disease. It is only very lately that authors have begun to recognise and include in their arrangements the class of blood-medicines, which seems to me to be considerably more important than any other.

Having shown thus what appear to me to be the correct basis upon which an arrangement of this kind should be constructed, I shall quote as another specimen the classification of Dr. John Murray, but mentioning only its most prominent details.

DR. MURRAY.

GENERAL STIMULANTS.

Diffusible { Narcotics. Antispasmodics.

Permanent { Tonics. Astringents.

LOCAL STIMULANTS.

Evacuants, Irritants.

CHEMICAL AGENTS.
MECHANICAL AGENTS.

We find in this division some reference made to the local tendencies of medicines. Evacuants are classed as Stimulants which tend to act locally on the glands. In the arrangement of Dr. A. T. Thomson, founded upon this one, still further reference is made to the local tendencies of different medicines. (See p. 26.) Dr. Paris has adopted the above arrangement, but in a very much improved form. So, too, has Dr. Royle. Both Dr. Thomson and Dr. Paris take exception to the inclusion of Sedatives (under the head of Narcotics) among General Stimulants. This is the great fault of Dr. Murray's classification. The idea, as he states, was taken from Brown. It is considered that both Stimulants and Narcotics act alike; that is, that they both produce a primary stimulation, followed by a secondary depression; only that, in the case of Narcotics (under which head all Sedatives are included) the stimulation is very brief, and rapidly passes away, to be followed by a great depression. Now, even if this were true, the most prominent action would be the depressing effect, and it is on the most prominent action that denominations such as these are usually based. But it is well urged by Dr. Thomson that in the case of true Sedatives there is no stimulant action whatever; and it is manifestly unreasonable to suppose that the depressing effect follows as a consequence on the primary stimulation, when the latter is so inconspicuous. At any rate such an arrangement as that of Dr. Murray can be of little practical utility in its original form. A man would be considered to be indulging in the wildest and most dangerous fancies who would run through the catalogue of Narcotics when he desired to produce a general stimulant effect. To this system it might further be objected, that Alteratives are again entirely omitted; and that the class of Mechanical agents would seem to belong to the division of Irritants, included among Local Stimulants. Dr. Murray classes Refrigerants among Chemical remedies, for which, when I come to speak of Acids, I hope to show that there are good reasons.

II. Opinions concerning the Local Tendency of Medicines, and Classifications founded upon this.

Here another step is made in the explanation of the action of medicines. They are said to have particular tendencies towards certain parts of the body, over which parts they exert a peculiar and special influence. It is thought that we shall make an advance in our knowledge of the subject, if we can discover what these tendencies are. An arrangement of medicines may be made accordingly. It is certainly more scientific than a merely empirical arrangement; and it will be so far of use that it will enable us, when we wish to make an impression on a certain organ or set of organs, to select those medicines which especially influence it or them. There is no doubt whatever of the existence of these local tendencies. There is no doubt that some medicines, such as Iodine, Bromine, Mercury, and Iron, tend especially to affect the blood and the blood-making organs, as the liver and spleen, rather than to act on the nervous or glandular systems; that some tend particularly towards the nerves, and prefer individually different parts of the nervous system, as Opium acts on the brain, Aconite on the superficial sensory nerves, Digitalis on the organic nerves of the heart, and Stramonium on those of the lungs. Again, it is evident that some medicines tend to act on the organs of secretion; and of these, particular sets select particular glands, as Diuretics the kidneys, Diaphoretics the glands of the skin, and Purgatives those of the bowels. There may be disagreements on minor points, but there can be no dispute as to the fact of the existence of these local partialities.*

But, though such statements are admitted to be correct in theory, it remains still to be considered whether they form a fitting basis for a classification of medicines. Now it will be observed that no theory of action enters into such an arrangement, but merely the tendency of the action of each medicine is considered; and as each medicine has naturally many distinct tendencies, it comes therefore under many different heads. But the chief practical use of a classification seems to be, that we may quickly learn from it the general action or effect of a medicine; so that, if it is stated to have many different tendencies, and is ranged under no one particular head, we can gain from this no very distinct practical information respecting it. In an arrangement of the kind that we have last examined, the most important result is the chief point considered. Thus it is rendered useful. And in one of the third kind, where the mode of operation is the great thing taken into account, as each remedy has only one primary operation, and according to this is classified, we gain from its designation some useful information respecting it. It may sometimes come under another head in its secondary operation, but only according to the primary should it be classed, the other term being supplementary. The designations founded on local ten-

* The whimsical "*doctrine of signatures*" which prevailed in the Middle Ages, and had its origin from very remote times, serves at least to show that the local tendencies of medicines have always been more or less recognised. So slight an experience is sufficient to demonstrate their existence, that it could indeed hardly be otherwise. It was oddly supposed that every natural substance bore evidence in its outward form or physical peculiarities of the part of the system over which it exerted a curative power.

dency are further, of an indefinite character, because they do not denote the kind of action exerted.

Of such a kind is the classification adopted by Dr. A. T. Thomson, founded on that of Dr. Murray. He divides what he calls *Vital remedies* into one division that acts on the nervous system, a second that affects the secerning system, and a third that influences the muscular and sanguiferous systems. This is certainly a step in the right direction. Nerve-medicines seem to have no relation to those that act on the glands, though connected with them as Stimulants by Dr. Murray. They are thus separated. Tonics are also separated from Stimulants, and included with those which act on the muscular and sanguiferous systems. This seems to me to be, in the main, a correct view of their action. I do not consider that they act primarily on the nerves, but on the blood. Dr. Thomson places Astringents beside them. Though alike in some points, as with regard to their tendency to affect the condition of muscular fibre, yet there appears to be very little agreement in the mode of operation of Tonics and Astringents. There is not altogether much similarity between Quina and Sulphuric acid.

I will now transcribe the chief divisions adopted in the classification of Eberle, which seems to have been the prototype of that one since so ably elaborated by Dr. Pereira.

Eberle's Classes.

A. Medicines acting on the intestinal canal or its contents.
B. Medicines acting on the muscular system.
C. On the uterine system.
D. On the nervous system.
E. In the circulating system.
F. On the organs of secretion.
G. On the respiratory organs.

The subdivisions are founded on the kind of effect produced. As in Dr. Thomson's arrangement, Tonics and Astringents are said to act on the muscles; but no mention is made here of either of them acting on the blood. While Narcotics are placed among nerve-medicines, Stimulants are classed as acting on the circulating system. They no doubt act on the nerves, and then through them on the vessels; but so also do Narcotics, from which they are separated. If in class E are only included medicines acting on the organic nerves of the heart and arteries, why were they not placed in D, with nerve-medicines? But if medicines acting on the contents of the vessels are meant, why were not blood-medicines or Alteratives, placed here? They are entirely omitted; which is certainly a fault in this system.

Dr. Pereira seems to have adopted a more correct view of both of these cases. He includes Stimulants with *Neurotics*, and places among *Hæmatics* those medicines which are commonly termed Alteratives. It seems to me that when a medicine acts on the blood, this action ought not to be thrown into the shade, but should rather be placed before all its other operations, as being of more importance than any of them. Dr. Pereira arranges in six classes those medicines which are given internally, having previously made three classes of external or topical agents, with which we are not now concerned. Some of the classes are again divided into large groups, these and the other subdivisions being either based on more particular local tendencies, or on the *physiological action* of the medicine on the part to which its operation tends.

Dr. Pereira's Classes.

Class. IV. Hæmatica.
1. *Spanæmica.*
2. *Hæmatinica.*

Class V. Pneumatica.

Class VI. Neurotica.
1. *Cerebro-spinalia.*
2. *Ganglionica.*

Class VII. Cœliaca.

Class. VIII. Eccritica.

Class IX. Genetica.

These groups, though differently placed, corespond to six of Eberle's seven classes. The class acting on the muscular system is omitted. The subdivision here is more accurate and scientific. *Hæmatics*, or blood-medicines, are divided into two classes. *Spanæmics*, the first of these, are named from their tendency to impoverish the blood. *Hæmatinics*, including the compounds of iron, tend to enrich it. In the first division are included the medicines commonly termed Alteratives, as well as Acids, Alkalies, the compounds of Lead, Silver, Copper, etc. In the selection of the above name, attention is paid to the abstract physiological effect of these medicines, rather than to their therapeutical applications. The impoverishing of the blood may be the ultimate action of such a medicine as Potash or Mercury, but it is not exactly the primary operation for which it is used in medicine. It is produced by the remedy when taken in excess, and not when given in small doses. *Neurotics*, or medicines which act on the nerves, are divided into those which affect the brain and spinal system, and those which are supposed to influence the ganglionic system, and through it, the heart and great vessels. (When we shall afterwards discuss the action of nerve-medicines, it will be seen that it is very difficult, if not impossible, to enforce this distinction.) The different kinds of Narcotics form the first division, while the second includes Stimulants and vascular

Sedatives. The class of *Eccritics* includes all medicines acting on the glands, commonly called Evacuants.

The details of this arrangement, to which I shall at present venture to object, are, first, the multiplicity of classes, and secondly, the inclusion of certain medicines in the division of *Cerebro-spinals.*

Three of the classes seem to be superfluous, and only tend to confuse. There is a class of *Pneumatics*, acting on the respiratory organs. But Expectorants are found elsewhere among *Eccritics;* and those medicines which influence the nerves of the lungs, among *Neurotics.* The same with *Cœliacs;* for Cathartics, found among *Eccritics*, are the most important medicines acting on the intestines. *Genetics* contain medicines which control the uterine and sexual systems, which may all be reckoned among *Neurotics.* And yet, this multiplicity of names is consistently employed in carrying out the principle of this classification, which is, to arrange according to the different parts of the system all substances which have any tendency to act on those parts.

Dr. Pereira makes four orders of *Cerebro-spinals;* three include different kinds of Narcotics, very minutely subdivided; another is called *Cinetics.* They affect the muscular system; but it is altogether an assumption to assert that these medicines, Astringents and Tonics, do so by influencing the nerves. As to astringents, it appears that they do not affect the nerves in any way, for which reason I shall have to make a separate class of them. For Tonics there is great reason to suppose that in the first place they act on the blood; so that I cannot agree with Dr. Pereira, who ranks them among *Neurotics.* Emetics are classed by him among *Eccritics;* but it seems to me that their action is either external, and of an irritant nature, or when from the blood, that it is exerted upon the nerves of the stomach. The stomach is not, like most glandular organs, a simple emunctory, and it is affected by medicines in a different way. Whereas, gland-medicines increase secretion, the chief action of Emetics is to cause an evacuation of the contents of the stomach by contraction of itself and of other muscles. All substances which touch the stomach cause the copious outpouring of a thin fluid by mere contact; yet we cannot for this reason call them medicines which tend to increase secretion. Emetics acting from the blood after absorption, as Tartar emetic, which generally influence at the same time either the lungs or the heart, parts supplied by the other branches of the vagus nerve, which is distributed to the stomach, seem to me to be Specific Neurotics, probably acting on that nerve. So that in these points, as well as in some others, I am disposed to differ from Dr. Pereira.

It is apparent that in none of the classifications of this second kind is any mention made of the primary action or *modus operandi* of medicines in the cure of disease, as a necessary basis of such distinctions. That which is distinguished by writers as *Physiological action*, *i. e.* the operation on a *healthy* man, is most taken into account. Whereas we naturally desire to be informed of the *Therapeutical action* of these medicines,—their operation on a *diseased* man. The agents being the same, the conditions are different, in these two cases; from which it results that these two kinds of action are often widely distinct. (See the preliminary remarks on Hæmatic medicines, in Chapter III.)

III. Opinions concerning the Mode of Operation of Medicines, and Classifications founded on this.

In this third division are included those writers who have attempted to account for the mode in which medicines produce their several effects after entering into the blood, and some who have classified them according to their ideas on this point. It is with such theories as these that I am more immediately concerned in this Essay. Such writers have dived into a deeper subject than that which engaged those who directed attention to the general effects or tendencies of medicines rather than to the means by which such results are attained. Thus it is not to be wondered at that they have sometimes failed. Those have erred most who have allowed their imaginations to lead them astray from facts, or to guide them in matters which are naturally incomprehensible, to which our reason gives us no clue.

Attempts have been made to account for the *modus operandi* of therapeutic agents generally, in three different ways.

1. On mechanical principles.
2. On chemical principles.
3. On general or vital principles.

1. *The action of one or more medicines may be explained on mechanical principles.*

Mechanical theories of the action of medicines were greatly in vogue during the seventeenth and eighteenth centuries. There is a tendency in the human mind to explain everything; and it was only natural that men who knew little of chemistry or of physiology should resort to the science of physics, which they could comprehend, in attempting the explanation of observed phenomena.

John Locke, in his Essay concerning the Human Understanding, published in 1689, gave it as his opinion, that the shapes of the minute particles of medicines were sufficient to account for their several operations.

"Did we know," said he, "the mechanical affections of the particles of rhubarb, hemlock, opium, and a man, as a watchmaker does those of a watch, whereby it performs its operations, and of a file, which, by rubbing on them, will alter the figure of any of the wheels, we should be able to tell beforehand that rhubarb will purge, hemlock kill, and opium make a man sleep." This idea did not originate with the great metaphysician. The first rudiments are to be found in the doctrines of the *Methodic Sect* among the Romans, a medical branch of the Epicurean school. They held that diseases depended either on constriction or relaxation of the tissues, and that medicines operated by mechanically affecting these conditions.

The simple and philosophical statement of Locke was not improved by the various applications which were subsequently made of it. At the early part of the eighteenth century these ideas derived great support from the principles inculcated by Dr. Herman Boerhaave, the learned physician of Leyden. He supposed that many diseases of the solid parts were to be attributed to a weakness or laxity of the animal fibres, and were to be cured by external or internal agents, which should act mechanically on those fibres so as to increase their tenacity. Also, that disorders of the fluids often depended on their being too viscid, and that this condition might be improved by agents which should attenuate this viscidity. Nor was the application of the principle limited to these cases. "Every medicine," said he, "produces its effects mechanically; namely, by the power of its solidity, bulk, figure, and motion of its particles."* Dr. Archibald Pitcairn, a Scotchman, the immediate predecessor and cotemporary of Boerhaave, was elected to the Chair of Physic in Leyden in 1691, and was also an able exponent of the mathematical theories. But he applied to physiology those ideas which were employed by the other to throw light upon physic; if that may be called *light* which was at least an improvement on the ignorance which preceded it.† He explained the digestive process by the mechanical trituration to which the food was subjected in the stomach; and accounted for secretion by supposing the existence in glands of vascular pores of different sizes, which intercepted certain particles of the blood; actually giving for the process a mathematical formula. He was a vehement opponent of those who based their theories on the then youthful science of chemistry, who, having scarce yet shaken off from them the dust of alchemy, only substituting Acids, Alkalies, and Fermentations, for *Salt*, *Sulphur*, *and Mercury*, fell easy victims to his satire.

Dr. Charles Perry, in 1741, propounded a mechanical view of the action of Mercury and Arsenic. He thought that the particles of the former, being round and heavy, were able,

* *Boerhaave's Treatise on the Powers of Medicines, translated by J. Martyn*, 1740, *p.* 13. See also the *Aphorisms of Sanctorius; Kiel's Medicina Statica Britannica; Dr. Quincy's Medico-Physical Essays*, 1720, etc.

† "He was one of the first who, leaving the old conjectural method of physical writers, struck into a new and more solid way of reasoning grounded upon observations and mathematical principles."—*Preface to Dr. Pitcairn's Works*, 1715.

when shaken about in the vessels, to break up and to annihilate those crude acrid humours which were the causes of disease; and that Arsenic acted as an irritant by the sharp and pointed nature of its atoms. He attributed the occasional poisonous effects of Mercury to the presence of Arsenic or some such substance as an impurity.*

Dr. Mead, in 1751, stated that the administration of mercury was dangerous in cases where there was carious bone, as there was a fear that its ponderous particles might break the weak lamellæ.† He was the Court Physician in the reign of George II. He accounted for the poisonous nature of the venom of serpents by asserting that it consisted of pointed particles, which pierced and destroyed the globules of the blood.

Dr. Perry conceived that some medicines, such as Steel and Antimony, did not act by their mere bodily presence, but by certain subtle vapours which emanated from them, and affected the vital spirits. This was a very misty notion. He stated that he borrowed this idea from a great philosopher of the German nation. This was probably Boerhaave, who lectured at Leyden in 1707.

Among those who regarded with favour the mechanical hypothesis were Fourcroy and Hecquet in France, Van Swieten and Huygens in Holland, and Bellini in Italy. Excepting perhaps the case of external irritants, these explanations of the action of medicines have been universally condemned by scientific men at the present day. Doubtless these old authors were in the wrong, both in applying one hypothesis to the action of all remedial agents alike, and still more, in carrying

* A Treatise of Diseases in General, wherein the true causes, natures, and essences of all the principal diseases incident to the human body are mechanically accounted for and explained, and their respective intentions of cure assigned upon the same principles," vol. ii. p. 313, 320.

† "Medical Precepts and Cautions," page 294.

their theories into such minute details, where it is impossible that they should be verified. And yet we may go too far in our condemnation of all such ideas. It does not seem to me to be so impossible, or even improbable, that the operation of some medicinal agents, particularly those which act on the nerves, may depend in some way on the shapes of the atoms of these substances, as related to those of the tissues which they influence. At least, there is no other more plausible explanation of the power of such substances. We know that the nerves are very much under the influence of mechanical impressions, upon which depend the phenomena of two at least out of the five senses, those of hearing and touch, as we should find probably also of the other three, if we understood them better. We know also that if we accept the Atomic theory, by which so many chemical phenomena are cleared up and explained, we must admit a certain definite and peculiar arrangement and shape to the ultimate particles of every compound body. Such considerations render it possible that the ultimate particles of a stimulant medicine may be of such a nature as to irritate, or to refuse to coincide with, the ultimate molecules of the sensitive nerve with which they come in contact; and those of a sedative may, on the other hand, be so shaped and arranged as to dovetail with those particles, and by extinguishing, as it were, their salient points, to cloak their vital sensibility. This is obviously a mere conjecture, and the only value which can attach to it is, that it appears in some sort to explain a thing which without it is inexplicable.

Some modern writers have attempted to clear up the actions of certain medicines by their supposed influence on the physical process of endosmosis, as carried on through the coats of the stomach and intestines. Poisseuille and Matteucci have attempted to prove that the action of saline liquids in causing purging, and that of a solution of morphia in preventing the same, may be explained by the *endosmotic* properties of these liquids, as ascertained by experiment. It does not seem to me that these ideas can be successfully maintained. (*Vide* Prop. II.)

2. *Several attempts have been made to explain the general action of medicines on chemical principles.*

Perhaps the strange doctrine taught by Galen, which prevailed for so many centuries afterwards, should be mentioned under this head, as the first approach to a chemical theory. He considered all medicines to be *hot*, *cold*, *moist*, or *dry*. There were four degrees of each of these properties. In the *Pharmacopœia Londinensis* of 1702, translated by Dr. Salmon, it is stated of every herb that it possesses in a certain degree one or more of these qualities. It is amusing to find Dr. Salmon in great doubt as to whether Opium were *hot or cold*, as the Ancients said one thing, and the Moderns another. Galen supposed that diseases depended on similar qualities, and were to be counteracted by medicines; that, for example, we were to meet a *hot* disease by a *cold* remedy.

The next advance, if such it may be termed, was made by the Alchemists of the middle ages, who frequently turned their attention towards the healing art, and almost imagined that by their *Philosopher's stone* they could purify and rekindle the perishable *base metal* of the human body. One of their dreams was, that from Gold, the most durable of metals, or from Mercury, the most lively and volatile, they might by their magical arts be enabled to prepare a medicine that should render life perennial. A most impracticable formula for the preparation of this *Elixir Vitæ* was given, among others, by Carolus Musitanus. Basil Valentine, who flourished in the fifteenth century, did good service by adding to the Materia Medica the preparations of Antimony, as well as the Mineral Acids. In the sixteenth lived Paracelsus and Van Helmont, the latest and most enthusiastic of the medical Alchemists.

They considered the chemical principles of medicines, by virtue of which they operated, to be three in number, viz., *Salt*, *Sulphur*, and *Mercury*. And though the seventeenth century was illumined by the philosophy of Bacon, and the discoveries of Newton and Boyle, we find that this strange doctrine survived in full vigour at the commencement of the eighteenth. It is laid down as an axiom in Dr. Salmon's Pharmacopœia in 1702.*

About the middle of this century there arose a new sect of chemical philosophers, somewhat better informed than the last. They imagined that most diseases depended on the predominance in the blood of *acid* or *alkalic humours*, and that each of these conditions should be counteracted by a direct chemical antidote. They supposed also that the various secretions were the products of *fermentations* in the blood which took place in the neighbourhood of the glandular organs. (*Vide* Eliminatives.) In some of their ideas there was much that was reasonable; but it must be confessed that they were rather imaginative than argumentative, and, knowing really but little of the principles of that science on which their system was ostensibly based, they were ill qualified to contend with their opponents of the mathematical school, who at least understood their own position. Foremost among these new chemical philosophers was Raymond Vieussens, who was severely censured by Dr. Pitcairn for having asserted that he had found an acid in human blood.† Vieussens was one of the earliest of the sect, which afterwards numbered many followers.

There is very little that is tangible to be discovered in these old chemical theories of the action of medicines; and it is not to be wondered at that most of them have faded away

* "If there be any bodies—suppose gold and silver—out of which all these principles cannot be drawn, let not the artist think that it is because they are not therein contained. No! it is because that God has so firmly united them against the possibility of our separation."—p. 809.

† Dr. Pitcairn's Works, 1715, p. 219.

before the advance of science, and particularly before that wonderful development of the science of chemistry, which has distinguished the end of the last, and the first half of the present century.

We have seen that some of the early writers made great account of the affinities of acids and alkalies. So also a chemical explanation of the action of these remedies is generally adopted by writers of the present day. It is known that they have powerful tendencies to combine with each other, and it is supposed that these affinities are manifested even in the living blood.

Schultz attempts a further chemical explanation of their action in some diseases, particularly inflammations. He says that both affect the condition of the blood; but that acids tend to dissolve and destroy the corpuscles, wherefore he terms them *Hæmatolytica Physoda;* and alkalies prevent the coagulation of the fibrine of the plasma, for which reason he calls them *Hæmatolytica Plasmatoda.*

Some modern writers have tried to extend a chemical theory to the operation of medicines in general. This is an error to which those who have devoted themselves particularly to the study of chemical phenomena are especially prone.

Müller thinks that the agency of many remedies may be explained by their chemical affinities. He supposes that they may effect a change in the nutritive fluids, or that they may so disturb the state of combination in which the elements of an organ may be, that it becomes insensible to the action of morbid stimuli. Some chemists have accounted for the action of Alcohol by its chemical affinity for the brain substance. Liebig considers that the similarity of their composition to that of the brain may serve to explain the operation of such medicines as Quina and Morphia. Such ideas as these are at the best purely hypothetical, and even as theories they seem to me to be untenable,—for what reasons I shall have to show when I consider these remedies. Liebig has hazarded several other explanations of a similar kind, of which the following is an example:—"The frightful effects of Sulphuretted Hydrogen and Hydrocyanic Acid are explained by the well-known action of these compounds on those of Iron, when Alkalies are present, and free Alkali is never absent in the blood." (*Organic Chemistry*, *p.* 274.) Now, in the first place, it is not proved that the complete abstraction of iron from the blood would occasion sudden death, though doubtless it is a necessary constituent of that fluid. Further, Prussic Acid acts on the superficial nerves as an anodyne when applied externally, which it can hardly do by displacing iron. Besides, by parity of reasoning, Ammonia, or Benzoic or Cinnamic Acid, should precipitate iron, if present in the blood in the soluble state, and Sulphuric or Nitric Acid should dissolve it, if in the state of peroxide; and yet none of these agents are frightful poisons. It is not to be imagined that chemical solutions and decompositions of every kind are allowed to take effect in the human system in the same way as in the laboratory of the chemist, for there are in the former many disturbing and controlling causes which suffice to hold them in check.*

Another theory by Liebig, that Alcohol and similar materials operate as Narcotics, by appropriating to themselves the Oxygen which should maintain the vitality of the tissues by entering into combination with them,—and a somewhat similar explanation of the action of Narcotic remedies, given by Dr. Snow and others, may be mentioned here among

* Mialhe, on the other hand, goes even further than Liebig, and considers that Vital Force and Chemical Force are in reality convertible terms. "The existence of organized beings consists in an uninterrupted succession of chemical reactions." (*Chimie appliquée à la Physiologie et à la Thérapeutique*, 1856, *p.* 8.) His theories as to the action of certain poisons and remedies, as Sulph. Hydrogen, Arsenic, and Prussic Acid, by virtue of an abrupt interference with the healthy process of *oxidation* in the blood, may, I think, be fairly placed in the same category as the speculations mentioned above. But of this more hereafter.

chemical theories of the action of medicines, but must be treated more at length in another place. (See *Narcotics.*)

We may for the present conclude, that though the actions of many remedies may be partly elucidated by chemical considerations, it is impossible to account for the influence of all alike in this way. For at least, as it seems to me, the actions of most nerve-medicines, and of gland-medicines, cannot be reasonably explained on any such hypothesis.

3. *The most plausible explanations of the mode of operation of medicines have been founded on vital or general principles.*

By *vital* I mean that these theories concern actions which could only take place in the living body. They may be termed *general* principles, because the grounds on which they are based are neither mechanical nor chemical, but something different from both. The term *dynamical* has sometimes been applied to an ill-understood vital action of this sort.

Many different ideas have been broached to account thus for the action of medicines. Some, who have constructed very ingenious and plausible systems, have explained in different ways the operations of different groups of medicines. But when others have adopted a single inflexible hypothesis to account for the action of all alike, this is found, as might be supposed, to be of a very untenable character. I will now consider very briefly several such ideas; first, for the sake of clearness, dividing them into seven sections. I shall explain my meaning as I proceed. Different writers have supposed that the general operation of remedies in the cure of disease is conducted in these various ways:

a. By degrees of stimulation.
b. By counter-stimulation.
c. By opposition.
d. By similar agencies.
e. By elimination.
f. By alterative actions.
g. By various counteractions.

a. This idea has received the title of the "Brunonian Theory," from the name of its founder. It was promulgated by the famous Dr. John Brown, at the close of the last century. He considered all diseases to arise from excessive or diminished "excitement." He was of opinion that all medicinal agents were stimulants, only that some acted so powerfully as to produce "indirect debility." These latter were to be used in sthenic, the others in asthenic disorders. But it is to be urged against this idea, that many sedatives produce no appreciable degree of "primary stimulation;" that alterative medicines are neither stimulant nor depressent; and that the actions of different therapeutic agents,—as, for example, of Opium, Mercury, and Rhubarb,—differ very much in quality, and not simply in degree, as Dr. Brown supposed. The principle, then, cannot be maintained.

b. Rasori and other Italians adopted a similar idea about the commencement of this century, only that they supposed two contrary agencies, instead of variations in the degree of the same action, like the Brunonians. Giacomini classified medicines on this plan. The two classes of medicines are termed "Hypersthenics" and "Hyposthenics,"—*i. e.* Stimulants, and Contra-stimulants or Sedatives. These were to be used respectively in asthenic and in sthenic disorders. But this idea did not originate with these physicians. It prevails among the modern Hindoos, and seems to have been inculcated by certain medical writers of that nation in very remote times. (*On the Hindoo System of Medicine, by Dr. Wise*, 1845, *p.* 213.)

c. The last-mentioned idea supposes only one kind of opposition, and therefore only two descriptions of diseased action. But a much more plausible notion than that is, that each particular disease or symptom is to be cured by administering a remedy which is capable of producing a contrary state. By this contrary condition the disorder is to be neutralized. This was the maxim of Hippocrates—τὰ ἐναντία τῶν ἐναντίων ἐστὶν ἰήματα—"contraries are the remedies of contraries." (De Flatibus, par. iii.) On this principle we give purgatives in constipation, opium in diarrhœa, sedatives to relieve pain, sudorifics to combat dryness of skin, etc., etc. But the rule becomes inapplicable when the cause of disease is so complicated that we cannot tell where to find a substance that shall directly oppose its agency. Besides it cannot in theory be universally applied, for it takes no notice of treatment by evacuation or by revulsion.

d. I am brought now to an idea which is directly opposed to the last. The rule of the disciples of Hahnemann is "Similia similibus curantur"—or, diseases are to be cured by remedies which shall produce effects similar to them. Now if this were the case, the majority of disorders would be hopelessly incurable. We know of no medicines that are capable of producing such affections as ague, small-pox, or phthisis; and when such remedies are known, their employment would certainly be singularly objectionable. Who would administer Strychnia in tetanus, Opium in congestion of the brain, or irritants in gastrodynia? The arguments alleged in support of the theory are of the most fallacious kind. For example, it is said that diaphoretics cured the sweating sickness, and purgatives are given with advantage in diarrhœa, on the "Homœopathic" principle. But it should be observed that the sweating in one case, and diarrhœa in the other, are the attempts of nature to get rid of the disease by eliminating a poison; and that in seconding these attempts we are availing ourselves of an agency which does not resemble the disease, but is like to the natural mode of cure. Such treatment depends, in fact, upon the principle which will have to be considered next in order.

The homœopathists would work a strange revolution in the Materia Medica.* Charcoal, Silica, and other substances commonly supposed to be inert, appear as remedies of wonderful efficacy. It is stated that Belladonna produces a state like scarlatina, and also a condition resembling hydrophobia, and thus cures both of these disorders. Of these three propositions it is almost needless to say that all are equally erroneous. Further, an experimental trial of this principle was made by Andral on a large number of patients at the Académie in Paris, with the assistance of the homœopathists themselves. The medicines were carefully and fairly administered, but in no one instance were they successful. (*Medical Gazette, vol. xv. p.* 922.)

e. The idea that diseases are to be cured by assisting nature to eliminate from the system the morbid material, is probably as old as medicine. It was one of the doctrines of Hippocrates; but long even before his time it appears to have been inculcated by a certain sect of old medical writers among the Hindoos. These last were the very earliest advocates of the humoral pathology. (*Dr. Wise, op. cit. p.* 212.) Dr. Thomas Sydenham, born in 1634, the contemporary of Harvey, and the most illustrious of the early English exponents of the humoral system, was probably the first in this country who clearly elaborated this view of the action of medicines by elimination, which has been more or less approved, though not so universally applied, by all who have lived since his time. Agreeing with Stahl in his view of the advantages of the "expectant" treatment of diseases, he thought it better to rely on the "vis medicatrix naturæ," than

* I have omitted here to make mention of the doctrine of infinitesimal doses, not only because it is out of my province, but because it is really too unreasonable to be even discussed. When it is said that the decillionth of a grain—the ordinary dose among these practitioners, is expressed by a fraction, the denominator of which is a unit followed by sixty ciphers, this statement will be surely enough for any man who is at all acquainted with figures. I do not conceive it possible that matter is *divisible* to anything like this extent.

to make rash or violent attempts at a cure. He maintained that what we call *a disease* was in fact "no more than a vigorous effort of nature to throw off the morbific matter, and thus recover the patient."* He proposed, therefore, that our efforts should be directed to assist nature to procure the evacuation of a poison, promoting its elimination by acting on the various secretions—as by purgatives, diaphoretics, and such medicines. For he had noticed that in fevers and febrile disorders the crisis or turning-point was generally accompanied or preceded by an increase in one or more of these secretions, and he regarded this as an indication of the treatment to be pursued in all such cases. "That," said he, "appears to be the best method of curing acute diseases, which, after nature has pitched upon a certain kind of evacuation, assists her in promoting it, and so necessarily contributes to cure the distemper."† He further proposes, that in the treatment of chronic diseases, when nature herself was slow in procuring this evacuation, we should seek for *specific* medicines, by which we might assist her in doing so, and thus effectually expel the morbific matter. This theory was reasonable and natural compared to those that followed it; but it was nearly extinguished and forgotten amid the war of opinions which was subsequently kindled by the *aphorisms* of Boerhaave. About this time, we find Dr. Pitcairn mixing up this idea with his mechanical notions, in a treatise, "On the cure of Fevers by Evacuation." Huxham also, in 1729, maintained similar principles.

At the present day a more enlarged view is adopted. It is admitted that we may often assist these attempts of nature at a cure, and do good by the use, when thus needed, of evacuant medicines; but at the same time we must allow that

* Sydenham's Works, translated from the Latin by Dr. Swan. 5th edition, 1769, p. 1.

† Preface to the same, p. 22.

there are many other advantageous modes of treatment,—that we may sometimes cut short a disease in the blood, or relieve a disorder by controlling vascular or nervous excitement, without resorting to elimination at all.

f. M. Broussais was one of the first who rightly maintained that many medicines were of use by means of an *alterative* or *revulsive* action, by producing a distinct effect which diverted the attention of the system from the disease. His followers have classed remedies under three heads,—as *Stimulants*, *Debilitants*, and *Revulsives*. He maintained also some other peculiar ideas.

Blood-medicines are commonly termed *Alteratives*, from the notion that they divert or alter the original disease by setting up in the system a peculiar process of their own. The term *Revulsive* is especially applied to medicines which produce a powerful local effect, and are supposed so to occupy the attention of the system as to tend to cure the disease which formerly engaged it. Counter-irritants externally, and emetics among internal medicines, are generally admitted as revulsives.

The idea of revulsion is a prominent feature in the arrangement of medicines adopted by Dr. Schultz, of Berlin, who adds to the above, Expectorants, Purgatives, Diuretics, and Sudorifics. He divides medicines into *Biolytics*, tending to dissolve life and structure; *Anabiotics*, which tend to stimulate the same; and *Agonistics*, tending to produce a "defensive" process, and acting by revulsion. Each class is again divided into those which affect the organs and nutrition in general; those which act on the blood; and those which particularly influence the nerves. I will give examples of each.

SCHULTZ'S CLASSIFICATION.

A. BIOLYTICA. (*Depressents.*)

1. Plastilytica.	(Mercury, Alteratives.)
2. Hæmatolytica.	(Acids, Alkalies.)
3. Neurolytica.	(Sedatives.)

B. ANABIOTICA. *Excitants.*

1. Plastibiotica.	(Astringents.)
2. Hæmatobiotica.	(Diffusible stimulants.)
3. Neurobiotica.	(Opium, Strychnia.)

C. Agonistica. (*Revulsives.*)

1. Plastagonistica.	(Purgatives, etc.)
2. Hæmatagonistica.	(Irritants.)
3. Neuragonistica.	(Emetics, Expectorants.)

These divisions are again subdivided with great minuteness according to their supposed operation. And yet it will be seen that in spite of the hard names there is an admirable simplicity in this arrangement. So many and so various are the statements made, and so plausible the theories involved, that I cannot accord to it here a fair consideration. I must object to it, however, that there is too much generalization, and, what is more important, that many medicines may cure diseases without necessarily causing either excitation or depression, or acting distinctly by revulsion. The only principles of action admitted here are these three, the same which are adopted by the disciples of Broussais. To suppose that medicines acting on the glands are only of use as revulsives, that they have no influence on the blood, and are never engaged in purging the system of peccant or morbid matter, is surely incorrect in theory. Medicines of the first class, when given in proper dose and in fit cases, are not engaged in *destroying* organization, nor is it invariably the case that such remedies as Mercury, Acids, and Alkalies act even as depressents, when given in moderation.

Further, the lines of distinction are too arbitrary, and drawn with too much precision. The variations in the action of different medicines are too many and too great to be thus easily accounted for, and we do not know enough about many of them to be able to define their operation so exactly. And there is no explanation at all given here of the special tendencies of some remedies, by which we are enabled to cure a great number of disorders.

g. The Hippocratic maxim was a step towards a correct solution of the therapeutical operations of remedial agents. The humoral theory of Sydenham, and the threefold action supposed by Broussais, were further advances in the right direction. But these views were all too confined. Correct as far as they extended, they did not embrace the whole range of the subject; for it is impossible to explain by any one of them the operations of all medicines.

Biassed by the satisfactory observation which he had made of the *modus operandi* of particular medicines, and misled by the insufficiency of his knowledge, each of these writers was tempted to apply the view which was applicable to a certain set to all remedies alike. Once persuaded of its sufficiency, he easily found arguments by which to fortify both himself and others against any subsequent objections.

The right course lies in a combination of these various theories, embracing what is true and discarding what is erroneous in each of them, and supplying what may seem to be wanting in the whole. None of these ideas being by itself perfect, the sounder reasoners of the present day are driven to suppose that there are *various* different ways in which medicines may *counteract*, and thus cure different diseases. This *counteraction* is distinct from *contrary action;* it may be direct or indirect; and it allows of any action in a medicine, tending to restore health, except in effect similar to the disease. Such a view was adopted by Dr. Cullen, the well-known Nosologist, who lectured at Edinburgh towards the close of the last century. He discarded all special and confined views of the operation of medicines, believing that they acted in many and various ways, all of which tended to the same end—to counteract the influence of the disorder. This is well exemplified in his admirable directions for the treatment of fever, in which he enjoined the use of a number of different remedies, varied according to the nature of the case, and progress of the symptoms.*

Dr. Pereira, the most learned and acute of modern English writers on this subject, appears, like many others, to have preferred a wide explanation of this description.

On such views my own statements are based. I suppose that a disease in the blood is to be met by agents in the blood, which directly or indirectly counteract it there; that disorders, generally temporary, which depend on nervous derangement, are to be benefited by remedies which affect the nerves; and in the same way that a laxity of muscular fibre, or a failure in

* "First Lines of the Practice of Physic." Fourth Edition, 1784. Vol. i. p. 126 *et seq.*

a secretion, should be treated by agents which especially possess the property of restoring to a right condition such parts or functions.

Concluding, then, that it is impossible to account clearly for the actions of most medicines on *Mechanical* or on *Chemical* principles, we are led to infer that their influence must for the most part be *Vital* in its nature—that it must be such as could only be exerted in the living body. Even then we are unable to fix upon any single rule or formula which shall be capable of accounting for the actions of all at once. So it seems that the only general explanation which we can offer of the *modus operandi* of medicines in the cure of diseases, is to say that they operate by *various counteractions.*

This, then, introduces my Third Chapter.

CHAPTER III.

ON THE GENERAL MODES OF ACTION OF THERAPEUTIC AGENTS INTRODUCED INTO THE STOMACH.

THE principal affirmations which I have to make on this subject are divisible into Ten Propositions, as seen in the Table of Contents.

The first four of these concern the general conduct of medicines after their introduction into the stomach, and before their passage into the blood. Some broad rules are laid down by which the course which they take must be determined. The action of some few on the mucous membrane is also defined.

The remaining six Propositions treat of the subsequent behaviour of those medicines which pass into the blood and fluids of the body. Of these, the fifth specifies their general course. The sixth states that they may undergo certain changes in the system. And the concluding four treat of the various modes in which these agents may operate in the cure of disease.

The first proposition lays down the great fundamental rule of the action of medicines through the medium of the blood and fluids.

PROP. I.—*That the great majority of medicines must obtain entry into the blood, or internal fluids of the body, before their action can be manifested.**

This is to say, that the mere contact of a medicine with the stomach is not in general sufficient for the production of its peculiar action on the system. It will be seen (Prop. IV.) that the only apparent exceptions to this rule consist of agents having a mere local action on the mucous membrane, for which simple contact is all that is required.

Even when acting on any part of the system removed from this mucous surface, as when applied to the skin, it is necessary that the medicine pass away from it to enter the blood or internal fluids. In the great majority of instances it enters the blood directly. But we know that it would be sufficient for its operation if it were to enter through the chyle, or into the serous fluid which exists in the interstices of the tissues throughout the body. For by these it might at length be conducted to distant parts. This is what is meant by *internal fluids.* For example, when a preparation of Aconite, or Opium, is rubbed on to the skin at any part, as soon as it has had time to penetrate the cuticle, it paralyzes the superficial sentient nerves. These are bathed in the interstitial fluid of the tissues. It is therefore very easy for the medicine to reach them without passing into the vessels at all, though when applied in large amount it certainly tends to enter them, and may then be carried along so as to affect parts at a distance. Similarly, Belladonna, or Atropine, which, when applied to the surface of the eye or the neighbourhood of the orbit, influence the nerves of the pupil in such a manner as to cause the latter to dilate, must in all probability find a more direct road to these nerves than that which is offered by the vascular system.

* "A remedy must be absorbed, before it can exert any remote action on the animal economy."—*Mialhe, L'Art de Formuler*, 1845.

We are not just now concerned with the way in which this passage into the blood and fluids is obtained. It is by the process of absorption. The question of passage by absorption is treated in the second and third propositions. What we have now to decide is, whether a medicine acts by mere contact with the stomach, its influence being propagated to distant parts by means of the nerves; or by passage thence into the system, acting through the medium of the blood and fluids.

I affirm that it operates in this latter way; and this is to be proved by four considerations, which we will take in succession.

A medicine introduced into the system elsewhere acts in the same way as when introduced into the stomach.

This proves at least that contact with the mucous surface is not an essential requisite for the operation of a remedy. We may cause a medicine to be absorbed by the skin, or inject it directly into an opened vein. The result of this latter experiment proves not only that entry into a distant part of the system is sufficient for the action of a medicine, but that it will operate when introduced into the blood. Numberless proofs of this affirmation may be adduced. Tartar Emetic injected into the veins produces vomiting. A moistened leaf of Tobacco, applied over the radial artery at the wrist, has been known to produce vomiting. Sulphate of Magnesia, infused into the veins of an animal, has been found to act on the bowels.* An infusion of Rhubarb, or Senna, injected into the thorax of an animal, will cause purging after a short time.† Or let Croton Oil, or a liquid preparation of Jalap, Rhubarb, or Gamboge, be rubbed in sufficient quantity on to the abdomen, and purging will be the result.‡ Mercurial ointment

* By Dr. Aubert. See British and Foreign Med. Chir. Review, January, 1853.

† Boerhaave.—*Op. cit.* p. 218.

‡ Ascertained by Dr. Madden, and others. See Paris's Pharmacologia, 9th ed., p. 141.

applied by friction to the skin will produce salivation. Extract of Belladonna applied to the temples causes dilatation of the pupil of the eye; and Tincture of Opium dropped on to the eyeball causes the pupil to contract. Ammonia inhaled as gas into the lungs will relieve fainting in the same way as when swallowed. The pungent vapour which emanates from living Cantharides has caused *ardor urinæ*. The breathing of Prussic acid, causing its vapour to be applied to the pulmonary surface, is sufficient to kill. Prussic acid, dropped in a concentrated state into the eye of a dog, causes speedy death. Solution of Aconitina, applied to the skin, will produce numbness and tingling of distant parts. Injection of Nux Vomica, or any powerful poison, into the veins, is rapidly followed by symptoms of poisoning, like those which would have followed its introduction into the stomach.* Thus contact with the stomach is not necessary, but introduction into the system anywhere is sufficient. But still, may not the poison in either case act by influencing the nerves? Even when it has entered the blood, it may not travel along in it, but act in a more direct way. So in the second part of the proof we must show that a remedy cannot act by an impression conducted from the surface of the stomach, or any other part, by means of the nerves alone.

The continuity of nerve is not necessary for the propagation of such effects; but vascular connection is necessary.

This alone, if established, would be sufficient to prove that a medicine must be introduced into the circulation, in order to act on distant parts. When confined to a surface, it can operate on the remote part only by its contact with the superficial extremities of the nerves. For vascular connection to be

* An exception should be made here of certain animal poisons, such as the venom of serpents, which, though they act on the system when introduced directly into the blood, seem to be rendered innocuous by the action of the stomach, which probably either decomposes them, or resists their absorption.

established, it must first enter the vessels. Many experiments have been made which demonstrate that the vessels are the only channel by which medicinal effects can be propagated.

M. Magendie introduced some Urari poison into the limb of a dog, which was only connected with the trunk by means of quills uniting the divided ends of the main vessels. It rapidly took effect. Having divided all the nerves and lymphatics in the intestine of another dog, he introduced into it some Nux Vomica, beyond the division. It quickly acted, and must again have done so through the vessels. Sir B. Brodie cut all the nerves of the anterior extremity of a rabbit, near the axilla, and then introduced Urari into the foot. It rapidly acted.* Thus we see that vascular connection is sufficient, and that nervous connection is not necessary. By other similar trials it is found that vascular connection is absolutely necessary, for when it is interrupted, the action cannot be propagated along a nerve. If, on introducing poison into an extremity, a cord be tightened round the limb above it so as to intercept the flow of blood, no effect is produced. It takes effect after the ligature is relaxed. Sir B. Brodie introduced Urari into the leg of a dog, which was connected with the trunk only by means of the principal nerve, carefully dissected out. No effect followed. Emmert found that poison would not act when applied to an amputated limb connected with the trunk by a nerve only. Also that Prussic acid, introduced into a wound in the foot, did not act while the abdominal aorta was tied. (Dr. Robinson has repeated this experiment with the same result.) Thus vascular connection is necessary; whereas continuity of nerve is not necessary, neither is it sufficient by itself.† Urari and Prussic acid are

* Physiological Researches, pp. 63—67.

† It should be mentioned that Sir Benjamin Brodie, though admitting the force of the above experiments, and deriving from them very similar inferences, yet considers it likely that the action of a medicine or poison may be *partly* propagated by means of the nervous system.—*Op. cit.* p. 127.

substances which act with great rapidity, on the nervous system; and if their action cannot be propagated by means of the nerves, *à fortiori* would it seem that slower poisons must act through the circulation. But, granting that it has been shown that introduction into the stomach is not necessary for the action of a medicine, and that when in the stomach medicines do not act by influencing the nerves, still it may be objected that the rule cannot possibly be universal. It may be urged that some poisons and medicines, as Hydrocyanic acid and Ammonia, act with such great rapidity, that we can only suppose their influence to be transmitted directly along a nerve-fibre to the nervous centre, because the process of passage in the blood to this distant part would be far too slow. We will not here rely on isolated experiments, which are always liable to more or less misconstruction. This argument requires us to prove a third thing.

The circulation of the blood is sufficiently quick to account even for the operation of those poisons which act most rapidly by influencing the nerve-centres.

There is no poison whatever which acts so quickly on distant parts that the circulation cannot previously have had time to conduct it to them. By means of an instrument invented by M. Poisseuille, Dr. Blake found that a chemical substance traversed the whole circulation of a dog in nine seconds, and of a horse in twenty seconds.* The results of Hering were similar. M. Volkmann, in the tenth chapter of his work on Hæmadynamics, states, as the result of several experiments, that the whole circulation in an adult man occupies exactly 65·76 seconds.

Now a poison that operated by nervous connection would probably operate directly it touched the stomach. This is not the case even with Hydrocyanic acid. This, the most sudden of all poisons, before it takes effect, allows sufficient time to

* *Vide* Paper in Medical Gazette, June 18th, 1841.

elapse for the blood to conduct it to the brain. Blake made an interesting experiment upon it. He placed some on the tongue of a dog, having first fitted a tube into the larynx, so as to prevent the vapour from passing into the lungs. The effect did not commence until sixteen seconds had elapsed, and forty-five were required for its completion. This allowed of time for absorption.

Thus it is proved that poisons act when introduced into the system at any point; that vascular connection is required for this action; and that the rapidity of the circulation is in all cases quick enough to account for it.*

But this last is only a proof of *possibility*, and does not by itself show that a substance may not nevertheless act through the nerves. And to the experiments on nervous connection some may object that no conclusions on this point can be drawn from trials made on isolated and exposed nerves. So we may imagine a person to be still incredulous as to the truth of the Proposition, that medicines must pass into the blood before they can act. But a fourth consideration will suffice to bring this probability as close as possible to a certainty.

The great majority of medicines have been detected in the blood, and found in the secretions formed out of it.

Having tried to prove that they must pass into the blood,

* I have repeatedly observed, when a dog or other animal has been poisoned by Prussic acid and the body opened *immediately* afterwards, that the blood and all the parts have smelt strongly of the poison, before the stomach has been opened. It is supposed by some, and with much plausibility, that highly diffusible and volatile poisons, such as Hydrocyanic acid and Conia, may reach the nervous centres (upon which they act) even more rapidly than by passing round in the blood, *i. e.* by at once permeating and mingling with the fluid or serous atmosphere of the system, by which means they may be at once conducted, almost in a straight line, to the part influenced. (See above, p. 64.) *Humoral connection* is probably an equivalent to the *vascular connection* mentioned above, and in such cases may be substituted for it. (But the motion of the fluid in the vessels seems at the same time to be a *sine qua non*, for compression of the abdominal aorta is said to retard poisoning by Prussic acid. See p. 67.)

if we find that they actually do so, we shall establish a stronger case. Isolated observations on this subject have been frequently made. Thus in 1847, Mr. Allen detected Daturia in the urine of a man poisoned by Stramonium. In 1824, M. Runge had discovered in the same way the principles of Henbane and Belladonna. Kletzinsky finds that if the throat be gargled for five minutes with the solution of any soluble mineral salt, its presence may be detected in the urine next evacuated. (*Wien. Med. W.* 1853.) M. Ragsky was the first to detect Chloroform in the blood. (*Journal für Prakt. Chem.* 1849.) This has since been done also by Dr. Snow and Dr. Taylor. Dr. Golding Bird observes that Indigo, when given for Epilepsy, has turned the urine blue; that Logwood also passes into it, and causes it to give a dark precipitate with solutions containing iron; and that during a course of Copaiba or Cubebs, a resin may be precipitated from it on the addition of Nitric acid. Krimer has detected Prussic acid in the blood of persons poisoned by it. Sulphur has been detected in the perspiration, Mercury in the saliva, when these medicines have been administered. Arsenic, Mercury, Antimony, and other poisons, may be detected after death in all parts of the body. Blood passing from the veins of an animal poisoned into the circulation of another animal, causes its death; and the flesh of animals which have eaten poisoned food, is poisonous to those who eat it. It would be easy to multiply such instances. Their bearing on the question is apparent. For if the medicine cannot be proved to pass into the blood or secretions, we cannot so certainly affirm that it does not act through the nerves. But the experiments of Tiedemann and Gmelin, and since then of Wöhler, have definitively settled this point. The former two have found the great majority of mineral, and many vegetable substances, in the blood of animals to which they had been administered.*

* See also a *Catalogue Raisonné* of medicines found in the blood, by Albers, in his *Handbuch der Allgemeinen Arznei-mittel-lehre*, 1854, *p.* 185.

Thus from these four considerations, we seem to be justified in concluding that a medicine must pass from the stomach into the blood before its distant action can be manifested.* Some experiments made by Dr. Garrod and others on the action of animal charcoal as an antidote, furnish again an additional confirmation of this fact. He finds that if a sufficient quantity of this absorbing agent be introduced into the stomach before time has been allowed for the passage of a medicine through the mucous membrane, then even such powerful nerve-medicines as Morphia and Strychnia, in very large doses, are prevented from taking effect. Yet before the contact of the charcoal they would have had time to act through the nerves, had they been capable of any such action.

In the Fifth Proposition the rule here laid down will have to be further extended. It will be shown that medicines, having already passed into the blood, must travel along in it so far as to reach the part of the system on which they act.

Before concluding this question, a few remarks must be made on a subject which will be again referred to in the discussion of the Fourth Proposition.

The proper and peculiar action of a medicine, by which I mean that action on the system which is immediately recognised as distinct from that of any other agent, cannot be exerted on distant parts from the stomach-surface, but requires the passage of the medicine into the circulation. But can any other action on distant parts be produced by the remedy while in the stomach? This is a different question, and must be answered in the affirmative. Suppose a Cantharides plaster be applied to the surface of the chest in a case of Pericarditis, so as to redden or blister the skin, absorption of the fluid in the pericardium may follow this application. But any other irritant would have done this. It is not the proper or peculiar action of Cantharides, but an operation of the nervous system which follows the local change. Such agents are

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* *Irritant Emetics*, which produce vomiting by exciting a reflex nervous action, are not an exception to the above rule. Their proper action is strictly topical, being exerted on the surface of the stomach. The nerve, and not the medicine, is concerned in the reflex action. It might be excited to this by any other irritant. (See p. 105.) These emetics may also be of use as counter-irritants (see above.)

said to act by *Counter-irritation*, or *Revulsion*, because it appears that as a consequence of their action, the attention of the nervous system may be drawn off from a morbid process going on at some other part of the body. But it is only a consequence, and not a direct operation. Such an effect is no more the action of Cantharides than the healthy functions following recovery from sickness can be ascribed to the remedy which has cured the latter.

Now, some few medicines have a marked local action on the mucous surface of the stomach and intestines. (*Vide* Prop. IV.) These, and these only, may, without passing into the blood, produce on distant parts an action of this kind by counter-irritation. Thus the operation of an irritant emetic may be followed by the arrest of some incipient inflammation, *e. g.* Ophthalmia. This revulsive action, when carried to an extreme, so powerfully impresses the nervous system, that it puts a stop to all other actions, and produces Syncope or Death. This extreme action is called *Shock*. Powerful corrosive poisons may effect this by a sudden destruction of the mucous surface, operating like a surgical injury. But such actions, not being the proper and characteristic operations of medicines, but rather attributable to a change in the relations of the nervous system, following a local impression, are not to be considered as exceptions to the above rule, that medicines cannot, from the surface of the stomach or intestines, propagate their influence to remote parts.

Prop. II.—*That the great majority of medicines are capable of solution in the gastric or intestinal secretions, and pass without material change, by a process of absorption, through the coats of the stomach and intestines, to enter the capillaries of the Portal system of veins.**

It has already been shown of medicines in general, that it is necessary for them to pass away from the mucous surface into the circulation. Mention has been made of their discovery in the blood by chemical means; and as we proceed it will be shown more particularly of different sets of medicines that each of them has been found in that fluid. Now, to gain

* It will be observed that these first three propositions are successive developments of the rule of absorption. The First states the necessity of absorption before a remote action can be manifested. The Second states that the great majority of medicines are soluble in the intestinal canal, and are there absorbed. The Third affirms that some few medicines are insoluble in the intestinal canal, and are there *not* absorbed.

entrance there, the medicine must first pass through the soft mucous membrane lining the stomach and intestine. This passage is performed by a process to which the names of *Absorption* and *Endosmosis* have been applied. Immediately outside this membrane, and between the tubes and cells which are formed by its involution, is a close network of very small veins, having thin and delicate walls. So that the same forces, whatever they be, which conduct the medicinal solution through the mucous membrane, cause it to pass on through the fine walls of these vessels. The two membranes, lying in such juxtaposition, are to all intents the same as one. Thus the medicine passes into the blood, and this is the only direct way by which it can gain entrance into it. These small veins or capillaries lead at length to the Mesenteric veins, which pour into the Portal vein, by which the blood proceeding from them is conducted to the liver. The process of Absorption is the only mode by which remedies can thus enter the blood; so that we have now to consider what the nature of this process may be, and to show in what manner and by what agents different medicines are fitted to undergo it.

The subject of this Proposition divides itself naturally into three parts. We shall have to consider—1. What is the nature, and what the function, of the gastric and intestinal secretions; 2. The laws of the process of Endosmotic absorption, and how they are fulfilled in this case; 3. The mode in which the great majority of medicines are reduced to a state of solution, which is necessary before they can be absorbed.

And it will then be shown that there is not (as has been supposed) any marked exception to this general rule of the absorption of soluble substances.

The process of stomach-digestion has been cleared up of late years by the decisive experiments of Spallanzani and Réaumur, of Tiedemann and Gmelin, and of Dr. Beaumont of Canada.

Immediately that a substance touches the mucous surface of the stomach, it causes the copious outpouring of a thin fluid, which is secreted by a glandular apparatus. This gastric juice is highly acid, and contains besides a peculiar nitrogenous substance called Pepsine. Dr. Prout thought that the reaction was due to free Hydrochloric acid. But the fact that it is due to *Lactic acid* has been long suspected, and may now be considered as established. Such at least is the opinion entertained both by Liebig and Lehmann.* Now the result of the action of this fluid is to dissolve down the solid materials of the food or other substances presented to it, reducing them to a thin watery pulp.† This pulp is then mainly absorbed; and that which is not taken up through the coat of the stomach is absorbed in the earlier portion of the intestinal canal. I shall have to treat of Aliments as one of the orders of Restorative Hæmatics.

We are now concerned with medicines in general. The same juice is poured out to receive them. Such as are dissolved by it are immediately absorbed. Some other matters may be rendered soluble by the agency of the Bile and Pancreatic juice which are poured out into the middle of the Duodenum. The former is an alkaline fluid, containing carbonate of Soda. The Pancreatic juice is also said to be alkaline.

That the stomach is absorbent may be proved by the experiment of placing a ligature round the intestine of a dog, just

* Lehmann found in six experiments that the quantity of Lactic acid in the gastric juice varied from ·098 to ·132 in 100 parts. The solid residue, besides this acid and Pepsine, contains also a considerable quantity of Chloride of Sodium, and smaller amounts of the Chlorides of Calcium and Magnesium.—*Physiological Chemistry*, vol. ii., Art. "*Gastric Juice.*" See also the recent experiments of Dr. Smith, of Philadelphia, on Alexis St. Martin, the Canadian. He found in his stomach-secretion no free Hydrochloric or Phosphoric acids, nor acid phosphate of lime,—only Lactic acid.—*Medical Examiner*, vol. xii., 1856.

† "Dans le suc gastrique il y a deux agents: l'acide, qui ramollit et gonfle la matière azotée; la pepsine ou la chymosine, qui en détermine la liquéfaction par un phénomène analogue à celui de la diastase sur l'amidon."—*Dumas, Traité de Chimie*, t. vi. p. 380.

below the pylorus. It is then found that soluble substances placed in the stomach pass rapidly from it into the circulation. It is probable that all substances which are easily dissolved pass through the coats of the stomach. That the surface of the intestines is absorbent may be proved by the disappearance of enemata thrown into them. Liebig states that a solution of common salt, in the proportion of one part to eighty of water, disappeared so completely in the rectum, that an evacuation one hour afterwards was found to contain no more than the usual proportion of salt. (*Animal Chemistry*, *p*. 77.)

On the mucous surface of the small intestine are a number of small projections, called Villi. Within these are the origins of the Lacteals, a peculiar set of Lymphatic vessels, which are engaged in the absorption of chyle. This chyle is a thick fluid which is formed by the meeting of the Bile and Pancreatic juice with that part of the digested food which passes into the Duodenum. It is generally white, from the presence of fat. Now these lacteal vessels are no doubt absorbent, but are they ever engaged in the absorption of medicinal solutions? It seems that they are not in ordinary cases at all concerned in this; for three chief reasons. In the first place it appears from the researches of Bernard and others that the lacteal system is a special arrangement for the absorption of fatty substances, and that other matters, such as albuminous compounds, pass for the most part into the veins, and thence to the liver. Besides, it seems that these lacteal absorbents are only in action during the digestion of food, when the epithelium on the surface of each villus becomes loosened, in order to allow to the chyle an easier access to the lacteal within it.* So that it is likely that a small portion of the fluid or soluble substance would be insufficient to rouse them to action. And, in the third place, direct experiments of a decisive kind have

* Todd and Bowman's Physiology, vol. ii. p. 230.

been made on this point. Magendie has found that the ligature of the lacteal trunks does not prevent the occurrence of poisoning from agents introduced into the bowels. And Tiedemann and Gmelin have carefully sought in the chyle for a number of different medicines administered to animals in their food, and have been unable to detect any of them there. So that, with the exception perhaps of fats and fixed oils, we may reasonably conclude that no medicinal substances pass into the system through the lacteals, but that all are absorbed by the veins or capillary vessels.*

It seems probable that the Bile and Pancreatic juice may be engaged in reducing to a soluble state certain medicines that are insoluble in the gastric secretion, and may thus procure the absorption of these substances by the veins of the intestinal canal.

Having briefly considered the secretions which meet the medicine on its first entrance into the system, we are next to inquire into the manner in which this medicine gains admission into the blood. In the first place it must be in a fluid state, or it cannot be absorbed at all. It will be most convenient to consider afterwards how different remedies are to be reduced to this condition.

Now the force or process by which fluids are enabled to pass and repass through an animal membrane, has been named by Dutrochet *Endosmose* and *Exosmose*, according as the current tends inwards or outwards.

There are fluids on both sides of the membrane. The circumstances which determine their passage are mainly five. 1. *The densities of the liquids:* other things being equal, the lighter of the two tends to pass through the heavier, more than the heavier to the lighter. 2. *Their attraction for the intervening membrane.*—That one passes through most which has the greatest affinity for the membrane. 3. *The affinity* of

* *Vide* Pereira's Materia Medica, vol. i. pp. 101, 106.

the fluids for each other.—A fluid passes through more rapidly when it is readily taken up and dissolved by that on the opposite side. By virtue of the last two laws, but contrary to the first, water passes through to alcohol more rapidly than alcohol to water. 4. *The motion of the fluid on one side* promotes the passage through of that on the other, because it is carried off as fast as it permeates the membrane. This also will cause endosmosis in defiance of the first law. This may be proved by a simple experiment. Let a large vein, cleanly dissected, be attached at one end to the stopcock of a vessel containing pure water. Let it then pass through a basin containing a strong solution of Ferrocyanide of Potassium, and let the other end hang over a jar filled with a solution of the Sesquichloride of Iron. If the cock be now turned, and the water be allowed to pass through the vein into the vessel beyond, the solution of Iron will quickly acquire the tint of Prussian blue; for the heavy solution in the central vessel has passed through to the simple water of the vein, mainly by virtue of the motion of the latter. It will be seen directly that this is a matter of considerable importance. 5. The last law is that *any pressure on the fluid on one side of the membrane* has a powerful influence in determining the passage of the current from that side. (See *Liebig's Animal Chemistry, p.* 72; *Liebig on the Motion of the Juices;* the *Lectures of Professor Matteucci of Pisa;* and *Dr. Robinson on the Circulation of the Blood, pp.* 54–62.)

The mucous membrane and the coat of the capillary vessel beyond it are probably subject to much the same physical conditions of absorption as those which are thus found by experiment to regulate the passage of fluids through dead animal membranes.

As to the first condition, it is probable that the aliment or medicine which is digested, however solid and dense, may be diluted down by the gastric juice until the solution is of less specific gravity than the serum of the blood. With the second law we are not so much concerned, as the medicine after solution has generally no repulsion for the animal membrane. So also with the third, as the serum of the blood mixes readily with all watery fluids. The fourth, viz. the condition of motion, is of great importance; for by it the motion of the contents of the capillary vessels will tend powerfully to determine the passage through of the liquid on the other side. Fifthly, the influence of pressure on endosmosis is one which is certainly exerted in the case of the stomach and intestines, which are muscular, and during the process of digestion contract on their contents with considerable force. It very much hastens the process of endosmotic permeation, which in experiments made on dead tissues, is found to be very slow.* This contraction, together with the circulation of the blood in the capillaries, would doubtless be sufficient to determine the passage of the digested matter inwards, even in opposition to the first law.

Under the first proposition I have shown that the majority of medicines are absorbed into the system. It is now seen where and how they are absorbed. But it still remains to be seen what particular substances or classes of medicaments are thus taken into the blood, and whether while so passing they undergo any modifications.

The following, then, are the chief classes which I believe to undergo solution and absorption in the intestinal canal. They comprise the great majority of all substances used either as food or medicine:—

* Such is the case in health, when the muscular pressure of the intestine must exceed the pressure on the vascular system on the other side. This latter pressure, when increased, tends to stop or to reverse the inward current. Thus plethora and fever, diseased conditions, counteract absorption by causing pressure on the coats of these capillary vessels. Bleeding,—a drain of fluid caused by an increased secretion,—or such agents as Tartar Emetic and Ipecacuanha, —diminish this pressure by weakening the force of the heart, and thus favour natural absorption.

1. Mineral substances soluble in water.
2. Mineral substances soluble in acids.
3. Mineral substances soluble in alkalies.
4. Vegetable products soluble in water.
5. Animal and vegetable substances rendered soluble by the gastric and intestinal juices.
6. Fatty and resinous substances soluble in alkali.

1. All soluble mineral substances,—acids, alkalies, salts, and soluble compounds of the earths and metals,—are absorbed in the stomach and intestines. The conditions of the process of absorption have been already stated. When solid they are first dissolved; when in a dense solution, diluted down by the gastric fluid before they are absorbed. Thin watery liquids are quickly taken up. Motion on one side, and pressure on the other, hasten the process.

Various precipitations and re-solutions are likely to occur between these solutions of mineral substances and the digestive fluids which are poured out to receive them. In no one case does an absolute neutralization or fixation of the foreign agent seem to result from its chemical incompatibility with the animal fluids. The mineral acids, salts of the metals, Alum, and the tannic principle of vegetables, must at first be more or less precipitated by the albumen and pepsine of the gastric juice. But Mitscherlich, in observations on the gastric juice of the bullock, found that the mineral salts were at the same time partially precipitated and partially dissolved by it. This latter portion may at once be absorbed from the stomach. The other portion may be rendered soluble, sometimes by an excess of the mineral itself, sometimes by the aid of alkaline matter in the secretions of the small intestine. The mineral alkalies, alkaline earths, and their salts, cause no precipitate at all with any of the animal fluids, but rather assist in retaining them in a fluid state. These, therefore, are named *Fluidifiants* by Mialhe, who entitles the others *Coagulants*. When these latter escape being fixed by combination with albumen in the stomach they must meet it as soon as they enter the blood—but there the coagulum, as fast as formed, is dissolved by the agency of alkaline or saline matter.

There are yet other chemical incompatibilities which may interfere with the solution of medicines in the stomach and intestines. The gastric juice contains Chloride of Sodium, and it has been supposed that the soluble salts of Mercury (Protoxide,) Silver, and Lead, must be necessarily precipitated by this in the form of insoluble Protochlorides. Mialhe supposes that the precipitate is then dissolved by the agency of some more of the alkaline chloride. This may be so; but I must consider it far from proved. A small dose of Nitrate of Silver is more efficient than a large dose of the Chloride, which is considered by Trousseau to be nearly inert. Thus we cannot imagine that the former changes into the latter directly that it enters the stomach. The Chloride of Lead, supposing it produced, is to some considerable extent soluble in water. The Chloride of Mercury may be dissolved, as I have found, by the agency of the bile. My experiments have caused me to doubt the possibility of the re-solution of these insoluble chlorides in the manner suggested by the French therapeutist. The salts of Mercury, Silver, and Lead, are doubtless absorbed. They may occasionally undergo partial precipitation by alkaline chlorides in the intestinal canal. But I cannot regard the reactions enumerated by Mialhe in the light of a general rule as to the manner of their absorption.

The intestinal secretions contain alkaline carbonates. These would precipitate a great number of the oxides of the metals from solutions of their salts, could they come in contact with them. But in many cases the metallic solution is at once absorbed from the stomach; and when the mineral descends to the small intestine, it is probably in the form of a coagulum or metallic albuminate, which waits for the action of an alkaline secretion by which it may finally be reduced to solution.

I believe we may thus conclude that all mineral substances introduced in a state of solution may be absorbed in the stomach or intestine, either in the same state in which they entered, or in some other soluble state which is its equivalent.

All minerals soluble in water are absorbed in the stomach and intestines. I am not inclined to make any exception to this rule. This leads me to make some remarks on *the Endosmotic theory of the action of saline purgatives.*

M. Poisseuille found that the serum of the blood would pass through an animal membrane to a solution of Sulphate of Soda of greater specific gravity. He thus concluded that an ordinary saline purgative of greater specific gravity than serum (1·028) acted by causing the passage of this serum outwards into the intestine, producing a watery evacuation. The theory was taken up by Liebig and Matteucci, and by Laveran and

Millon. Dr. Pereira and Dr. Golding Bird have drawn some practical inferences from it.

It is said that when a saline is absorbed it produces diuresis, and no purging; that when it purges it is not absorbed; that when given to act on the kidneys, the solution should be so dilute as to contain less than five per cent. of the solid; and when administered as a purgative, the specific gravity should be considerably above 1·028. Now, I do not deny that a weak solution is more likely to pass off by the kidneys, and a dense one by the bowels; but I consider this due to the fact, that the kidneys are the proper emunctories of water, and of such matters as are soluble in it. But I believe that these solutions are equally absorbed, both heavy and weak, and that the purging or diuretic effect depends mainly on the quantity of the salt, as the kidneys will not eliminate beyond a certain amount of it. I must allege, to support this view of the question, firstly, some arguments *à priori;* and secondly, some experiments which I have made to satisfy myself. To consider first the former. Analogy is certainly against this theory. Other purgatives from the vegetable kingdom produce their effect when injected into the blood, and are yet often powerfully hydragogue. What effect on the process of endosmosis can be exerted by Castor or Croton oils, or by calcined Magnesia? On turning to what we know of the theory of digestive endosmosis, we find that the solid parts of the food are diluted down so as to be absorbed, and that the influence of pressure is to be taken into calculation. It was laid down by the great Boerhaave that a necessary requisite for the formation and absorption of chyle was the contractile force of the viscera. (*Van Swieten's Comment.* vol. i. p. 290.) This, in fact, would press the fluid into the absorbent vessels, even if against the other endosmotic forces. Further, a fundamental principle was insisted on by Dutrochet—that even when the liquids on the two sides varied in density, they would both pass through to each other, though in different proportions. The ultimate result of this would be, that a heavy saline solution would be diluted down to the specific gravity of the serum, and would then pass through.* This point I have illustrated in my first experiment. Thus it seems that my view is favoured by these physical laws. But even if it were not so, I should not be inclined to admit that all the endosmotic processes in the living body were regulated by merely physical tendencies. This cannot be the case with some of the secretions. The bile is of higher specific gravity than the serum of blood. Urine in health is lower, but in diabetes often much higher. The production of these secretions, differing in density from the serum of blood, would be inconsistent with the first law of endosmosis. Lastly, we find that in many known cases the theory which I am contesting does not hold good. Seidlitz-water and Sea-water are both known to be purgative. In both the specific gravity is *below* that of the serum of blood.

The first, according to Bergmann, has a density of 1·006. It contains in each pint 192·8 grains of solid matter. Out of this, 180 grains consist of Sulphate of Magnesia.

Sea-water has a specific gravity of 1·026, and its solid contents are about 3·5 per cent. But Dr. G. Bird says that less than five per cent. of saline matter constitutes a liquid diuretic.

These then are strong reasons against this idea considered merely as a theory. But it can readily be put to the proof. With this purpose I have made the following experiments. Their object is to show that salines are in all cases absorbed, and that whether they are subsequently excreted through the kidneys or by the bowels depends more on the quantity administered than on the degree of dilution of the dose.

* Bidder and Schmidt state that the digestive fluids secreted into the intestinal canal during twenty-four hours amount to one sixth of the weight of the body. This would surely suffice to dilute down any amount of ingesta to the required standard.

Exp. 1.—A sufficient quantity of white sugar was dissolved in four ounces of water to raise its specific gravity to 1·028, that of the serum of the blood. A sufficient quantity of Sulphate of Magnesia was dissolved in another ounce of water, to render it of the density of 1·060. This heavier solution was introduced into an open wide tube, closed completely below by a clean piece of bladder. It was introduced into a small vessel containing the solution of sugar, and arranged so that the height of the two liquids should correspond. After standing for some time, the inner solution measured two drachms more, and the specific gravity had sunk to 1·050. The outer solution, after making up exactly the loss by evaporation, was found to have risen in density to 1·040. On adding a small quantity of each of the solutions of Phosphate of Soda and Carbonate of Ammonia, a copious precipitate took place, indicating the presence of magnesia. Thus it appeared that the fluids passed both ways, some of the heavy solution of magnesia finding its way through to the lighter solution of sugar. The tendency of this process was evidently to an equalization of their densities, both by endosmose one way, and by exosmose the other. Thus, apparently, would it be with a saline purgative, and with the serum of the blood.

Exp. 2.—Three drachms of Sulphate of Magnesia (a very mild purgative dose) were dissolved in ten ounces of water, and thus administered to a healthy young man. It produced, after some time, slight purging, and some diuresis. The urine, when tested, contained only a very little more than the usual quantity of magnesia. The quantity in the dose was less than five per cent. of the solution, and thus, according to the endosmotic theory, should have produced no purging.

Exp. 3.—Six drachms of the same salt were given in eighteen ounces of water to the same patient. After a few hours it caused very copious and long-continued watery purging. The urine did not seem to be increased, and contained no excess of magnesia. It seemed, that in spite of the dilution, the quantity of the salt was so large, that it could not pass off by the kidneys, and so was eliminated from the blood by the bowels, in the same way as other purgative medicines. (*Vide* Cathartics, and Chap. IV.)

Exp. 4.—This trial was the reverse of the last. Two scruples of Acetate of Potash were dissolved in three drachms of water, and thus administered. The solution then contained about twenty per cent. of the salt. According to the endosmotic theory, it should have caused only slight purging, on account of its density. It did not do so, but produced diuresis. The dose was so small, that after absorption it was easily eliminated by the kidneys. The alkalinity of the urine which resulted was a proof of the absorption of the salt, and its passage into this secretion in the form of a carbonate. (See Prop. VI.)

Exp. 5.—(In Chap. IV., Art. Sulphate of Magnesia, will be detailed some experiments designed for the purpose of still further demonstrating the *modus operandi* of this salt and others like it. One of these may be quoted here, as bearing directly upon the subject in hand. It proves that a dense solution of Sulphate of Magnesia is absorbed in the intestinal canal.)

Three drachms of Sulphate of Magnesia, dissolved in three ounces of water, forming a solution having the density 1·060, were injected down the throat of a healthy dog. It was killed after three-quarters of an hour, and the whole contents of the stomach and intestines, none of which had been lost either by vomiting or purging, were subjected to a careful analysis. The result showed that only fifty-five grains of the salt remained out of the three drachms. The rest must have been absorbed into the blood.

To sum up these experiments. The first shows how, in an experiment made out of the body, a dense fluid will pass through to a light one on the opposite side of a membrane, the densities of the two being at the same time gradually equalized. The second and third demonstrate that a solution of low specific gravity will occasion purging, whereas, according to the *Endosmotic theory*, it should not do so. And the fourth and fifth show that a dense solution is absorbed; whereas, according to the *Endosmotic theory*, it should not be absorbed.

These experiments are in favour of my views, and certainly cast discredit on the theory of Poisseuille.*

I believe, as I have before said, that Sulphate of Magnesia, Sulphate of Soda, and all soluble salines, are invariably absorbed in healthy conditions of system, whether they prove purgative or not purgative. It has been just shown that a dense purgative dose of Epsom salts is rapidly absorbed in the intestines,—so, *à fortiori*, must a weak solution be so disposed of.

There are other more indirect proofs of this absorption, as occurring

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* "We assent to these conclusions in the main, and we cannot avoid expressing our astonishment that a doctrine founded upon such unsatisfactory data as M. Poisseuille's experiments with the Endosmometer should have received so ready an assent as it has done in some high quarters."—*Review in Monthly Journal of Medical Science.*

"As confirmatory of these experiments, we may add that it having occurred to us that if this endosmotic theory were true with respect to the intestines, which have a compound structure, it might also apply to other parts, more especially if greater length of time could be allowed for its operation,—accordingly, in a case of ascites in a patient with very thin integuments, we kept a solution of salts of great density constantly over the abdomen, but there resulted neither diminution of the fluid from within nor increase of that without." (!)—*Review in Dublin Quarterly Journal of Medical Science.*

with purgative doses. (Of course a diuretic dose, after which the salt is discovered in the urine, must have passed through the blood.)

Schultz found, in a man who took one ounce of Sulphate of Soda each day for two days, that the amount of fibrine in the blood was lowered from 5 to 1·9 in 1000 parts. This must be explained by supposing that the antiplastic saline, by its entry into and presence in the blood, had hindered the formation of this fibrine. Again, it is well known that the action of a purgative dose of Epsom or Glauber's salts is materially aided by any condition that favours absorption. A small dose will suffice, if given on an empty stomach before breakfast. And combination with a minute proportion of Tartar Emetic, which aids absorption by relaxing the vessels, will often powerfully assist the operation of a purgative.

Since the above experiments were made by me, some others of the same kind have been instituted by two German physicians, Aubert and Buchheim.

Aubert has arrived at the same conclusion as myself in every particular. He shows that the operation of a purgative saline does not depend in any way on the density of the solution. He also believes that such purgatives act after entry into the blood, for he finds that a solution of Sulphate of Magnesia injected into the veins of a dog, causes purging. (*Zeitschrift für Rationelle Medizin*, 1852.)

The inquiries of Buchheim seem to have been very ample, and very carefully conducted. He, too, finds that a sufficient dose of Epsom or Glauber's salts will produce purging, whatever the degree of dilution. That when it purges less, or not at all, it passes out in the urine, producing diuresis. That when combined with a sufficient dose of Morphia or Tannic acid, no purging is produced, the salt passing out in the urine. (This I believe to be because these agents retard the *excretion* of the salt by means of the lower bowel.) When it purges it passes out with the fæces. (*Vierordt's Archives*, 1854, *Part I.*)

In opposition to the statement of Aubert, Buchheim asserts that a half-ounce dose of Sulphate of Soda, dissolved in water and injected into the jugular vein of a dog, did not cause purging, but passed out in the urine.

And in another important point I beg to differ from him. He supposes that the saline, which is found by him to pass out along with the fæces, has remained in the intestinal canal from the period of indigestion; whereas in my experiments on Sulphate of Magnesia (see Chap. IV.) it is shown that the salt is first absorbed (probably in the stomach and duodenum,) and afterwards again excreted into the bowel (probably at the lower part of the canal.) So that in place of remaining all the time in the cavity of the intestine, the saline fulfils in succession two important therapeutical rules,—the first, that all soluble matters must be absorbed; the second, that all materials which increase a secretion must themselves pass out of the system along with that secretion. (See Eliminatives.)

It is stated by Dr. Carpenter that if a ligature be applied below the pylorus of an animal, and Sulphate of Magnesia then introduced into the stomach, purging is produced. This could only be by the absorption of the salt, and its subsequent action from the blood on the mucous membrane of the bowel below the ligature. This experiment is unauthenticated, but, if verified, would certainly be strongly in favour of the view adopted by me.

Mialhe, in his late work (*Chimie appliquée à la Physiologie et à la Thérapeutique*, 1856,) contravenes the statement of MM. Laveran and Millon,—that Rochelle salt is never absorbed and never passes into the urine when given in a dense solution, whatever be the dose. He finds, like Wöhler, that it always renders that secretion more or less alkaline, *i.e.* that it is absorbed, and the alkaline carbonates formed by its oxidation in the blood are eliminated through the kidneys.*

This point being so far settled, and there being no physical reason why any other soluble mineral substance should not be absorbed—it being moreover proved, by repeated experiments, that they all pass into the blood—we therefore proceed to the second class of bodies capable of absorption.

2. Mineral substances soluble in acids.—It is apparent that if any insoluble substance will admit of easy solution in the fluids of the stomach and intestines, it may be brought to the condition of a soluble one, and thus absorbed. Now the gastric juice is acid. This reaction has been variously ascribed to free hydrochloric, acetic, phosphoric, and lactic acids; also to an acid phosphate or lactate of magnesia. There is every reason to conclude that this acid is Lactic acid, which would be easily formed out of the constituents of the food.

But we have now only to regard the gastric juice as containing a free acid. This would reduce to solution the carbonates and oxides of all the metals; less perfectly when anhydrous, more easily when in the hydrated form. In this

* "Nous ne sommes pas arrivé aux mêmes résultats (que M. Laveran;) nous avons reconnu que, dans *tous les cas* d'administration du sel de seignette, il y a absorption du sel et alkalisation de l'urine."—p. 674.

manner are probably absorbed the oxides of Iron and Silver, the carbonates of Lime and Magnesia, and other Medicines of the same kind. They would be slightly modified, being absorbed in combination with the (lactic) acid of the stomach. In this they would differ somewhat from the substances already soluble, which would probably be absorbed unchanged (or in combination with albumen,) unless we accept the alkalies and their carbonates, which might be similarly decomposed. Even these, if given in solution, would probably be dissolved faster than the gastric acid could be secreted to neutralize them.

Other insoluble substances, such as the metallic sulphurets, might be more or less dissolved by the action of this acid. But as a great part would necessarily escape its influence, being propelled onwards by the muscular contraction of the stomach, it follows that insoluble substances of this kind are much less active as medicines than similar compounds introduced in a soluble state. It is also likely that a certain quantity would be sufficient to exhaust for a time the acid gastric secretion.

We now pass on to a third class of mineral products, which though insoluble both in water and in acid, yet being soluble in alkalies, appear to be in this way prepared for absorption.

3. Mineral bodies insoluble in water and in acid, but soluble in alkalies.—These remain unaffected by the action of the gastric juice, but on passing on as far as the centre of the duodenum, they meet with two alkaline fluids. These are the bile and the pancreatic juice. We know that some such insoluble bodies pass into the blood. It will be shown in the proof of the next Proposition, that they cannot do so without being first dissolved. Therefore, there must be in the intestinal canal something capable of thus dissolving them. For this purpose these two alkaline secretions are well adapted. As an example of such mineral bodies, I may adduce Sulphur. It unquestionably passes into the blood, and is found there in

combination with alkalies, as a sulphuret or sulphate. It has been detected in the urine of those who were taking it, by Dr. Ronalds and others. Although it has been questioned by Laveran, there is, I think, no mineral substance of whose absorption we possess a more complete proof. It is probable that Iodine, Bromine, and some of the hydrated metallic oxides, enter the blood in the same way. So, without doubt, does Arsenious acid, which is rendered absorbable by conversion into a soluble Arsenite of Potash or Soda. We may add to this list the insoluble Albuminates, *e. g.* those of Copper and Antimony, produced by the contact of the gastric juice with the solutions of the metals. These are again rendered soluble by means of the intestinal alkali. (See above, p. 79.)

Though I have not myself thought it right to do so, I must observe that some would add here another group—*Mineral substances soluble in alkaline chlorides.* The only minerals of importance to which this could apply are the insoluble Chlorides of Mercury and Silver. Calomel is a medicine of great interest; but the Chloride of Silver is seldom or never administered designedly, though no doubt this insoluble material is generally formed to some extent in the stomach when the solution of Nitrate of Silver is given internally. Mialhe conceives that all the soluble salts of Mercury (Protoxide,) Silver and Lead, are precipitated as insoluble Chlorides by the gastric juice immediately that they enter the stomach. (*V.* p. 80.) As the Chloride of Lead is somewhat soluble in water, we may confine ourselves to the question of the solution of Calomel and Chloride of Silver.

That the gastric juice abounds in alkaline chlorides, especially the Chloride of Sodium, has been proved by the researches of Lehmann. It is upon the presence of this agent that Mialhe chiefly relies in framing an explanation of the mode of absorption of the above-mentioned substances. But Bouchardat rejects this salt, and fixes upon Chloride of Ammonium as the probable solvent. And Œttinger, who has experimented upon the subject, throws doubt upon the whole matter, and considers that none of these agents is present in sufficient quantity.

When boiled in pure water for a long time, a small proportion of Calomel is dissolved in the form of Bichloride, as has been ascertained by Donovan, a Subchloride (Hg_2 Cl) being probably produced at the same time. But if boiled with a solution of an alkaline chloride, this solution of a part of the Calomel takes place sooner; some Bichloride being again produced, or a soluble double chloride of Mercury and the alkaline metal. The Chloride of Silver is said to undergo a similar change.

Mialhe supposes that in this manner a Bichloride is formed out of a part of the Calomel ingested; that this is then decomposed by albumen, with the formation of an insoluble compound; and that this albuminate is lastly dissolved by means of the alkaline chloride, and in this condition absorbed. Some similar process, it is thought, takes place with the Salt of Silver.

To all which I object—firstly, that the chlorides in the stomach are probably not present in sufficient amount to work all these changes. Secondly, that the experiments of Mialhe upon Calomel were made with a mixture of the Chlorides of Sodium and Ammonium, the latter salt not being, I believe, present in such quantity in the gastric juice as to be able to take any part in such a process, and the Chloride of Sodium, as I have found, being insufficient alone, at least at the temperature of the stomach. Thirdly, that the explanation appears to me, circuitous, and inferior to others which may be alleged with at least equal plausibility.

In devising experiments to satisfy myself on this matter, I was at first not sure whether Calamel might not in some degree be dissolved by the action of Lactic acid; or whether the Pepsine, or the Albumen in the gastric juice, might form with it some slightly-soluble combination. Again, Glucose, (or Grape-sugar) is probably always present during the act of digestion. Robin and Verdeil have found that a large number of very insoluble minerals (including Silica) are taken up to some extent by a solution of Glucose; perhaps Calomel also would be soluble in this way. But I found that neither Lactic acid nor Glucose, nor a solution of Chloride of Sodium (5 per cent.) would take up any appreciable amount of Calomel, though digested upon it for twenty-four hours at a temperature of 100° Fahrenheit. I then made trial of fresh Ox bile, and found that some of the Chloride was dissolved by it. So, in default of other means, I am most inclined to look at *the bile* as the digestive fluid, by which the absorption of Calomel is effected. (See Chap. IV., Art. Mercury.)

This last explanation, if found to be the correct one, would perhaps throw some light on the remarkable variations observed in the therapeutic effects of Calomel in different diseases and states of the system. In some diseases, as Fevers and Cholera, where the biliary secretion is deficient or faulty, it is often not absorbed at all. And it seems to obtain entry into the system of adults more readily than into that of young children.

4. Vegetable substances soluble in water.—These would be absorbed with more or less readiness according to their degree of solubility. They would probably be taken up in great part

by the stomach. Some vegetable matters—as Lignine,* or woody fibre, and resins—are insoluble in water. Starch even is comparatively insoluble, and thus comes under another division, being probably one of those vegetable substances which are rendered soluble by the aid of the digestive fluids of the intestine.

These soluble vegetable matters are of several kinds. Cane-sugar and grape-sugar are readily soluble.† So also are the various vegetable acids. There is another class of bodies which is highly important in a medical point of view. These are the natural salts of the vegetable alkaloids, of which are constituted so many of the active principles of plants. In pharmaceutical operations we are enabled by the judicious employment of different menstrua, to extract from the crude and inert mass these vegetable active principles, and thus to obtain in a concentrated form the medicinal power for which each plant is esteemed. This process is also performed in the stomach. By digestion and concoction, with or without the aid of acid, it is enabled to dissolve out these soluble and potent matters, from the ligneous and bulky tissues which surround them. For though the alkaloids themselves are in general mostly insoluble in water, yet their natural salts which occur in the vegetable kingdom are very soluble. The most important of these salts, are as follow. In Cinchona bark, the Kinates of Quina and Cinchonia. In Opium, the Bimeconates of Morphia and Codeia. In Nux Vomica, the Igasaurate of Strychnia. In Aconite, the Aconitate of Aconitina. In Colchicum and Sabadilla, the Supergallates of Colchicia and Veratria. There are some neutral soluble substances, not partaking of the nature of Alkalies. Thus we find in

* Lignine, or Cellulose, is probably digested by some animals, (as the beaver,) which have the power of converting it, like starch, into Dextrine.

† Lehmann doubts whether Gum, though soluble, is ever absorbed.

Ipecacuanha, and Ionidium, Emetine; in Tea and Coffee, Caffeine; in Willow-bark, Salicine; and the soluble active principles of Senna,* Aloes,* and Gentian, are probably of the same nature. Many other alkaloids are known. Atropia in Belladonna, Daturia in Stramonium, and Hyoscyamia in Hyoscyamus, occur in combination with Malic acid. Conia in Hemlock, and Nicotia in Tobacco, are peculiar volatile alkalies, containing no Oxygen: thus in two respects they resemble Ammonia. They too, are soluble in water.

Alcoholic and Ethereal fluids may be enumerated here as soluble products of the vegetable kingdom. Alcohol mixes with water to any extent; and one part of Ether is soluble in ten parts of water. Nitric Ether and Chloroform are also sufficiently soluble. So is Creosote, 1·25 parts of which dissolve in 100 of water. But this may be absorbed in another way, as will be seen presently. Volatile Oils and Turpentine come also under this head. They are all slightly soluble in water. The former, when given in small doses, are probably absorbed in this way. Turpentine, when given in large doses, may perhaps, by undergoing a change, come under the head of vegetable substances dissolved by alkalies. Camphor may be included here: one part is soluble in 1000 parts of water.

The soluble saccharine and gummy matters of plants, when added to the substances enumerated above, constitute an aggregate which is called the *watery extractive* of a vegetable product: *i. e.* that part which is capable of being dissolved out of it by pure water.

But there are other active parts of vegetable, such as oily and resinous matters, and some neutral acrid principles, which before they can be dissolved by water, require the aid of an alkali. These will be considered separately.

* It is not yet quite decided whether *Cathartine* and *Aloine* are to be regarded as the true purgative principles of these drugs. (See Royle's Materia Medica, 3rd edition, pp. 397, 659.)

We now arrive at a fifth class of matters, which are taken up by absorption.

5. Animal and vegetable products dissolved by the gastric and intestinal juices.—First and most important of these are the nitrogenous and nutritive constituents of the flesh of animals and of the parts of vegetables. Albumen, Glutine, Fibrine, and Caseine are connected together as compounds of Proteine. Animal Fibrine and the analogous Glutine of vegetables, are quite insoluble in water. Albumen and Caseine, though soluble, are immediately precipitated by acids. This is known to be at first effected by the gastric juice on their entry into the stomach. But the action of the gastric juice, which contains an acid, and a peculiar nitrogenous material, called Pepsine,—together with the temperature of the body, which is about 100°,—causes at length the gradual solution of these previously insoluble matters. This is found to take place out of the body when the above conditions are imitated with an artificial gastric fluid. The result of the process is a viscid fluid, which is then absorbed. The hard Gelatine of gristle and bone is not soluble in water at this temperature, but is readily soluble in the acid gastric juice. The Pepsine seems to be an important agent in this process of digestion, for an acid by itself is found to produce an imperfect solution. The nitrogenous matters thus digested and absorbed, constitute that portion of the food which is of most use in the nutriment of the system; for the starchy compounds cannot be appropriated to the more solid tissues, although in some cases they may be converted into fat, as in herbivorous animals. (Liebig's *Animal Chemistry*, p. 113.)

It appears that the acid first coagulates and swells up the albuminous matters of the food; and that then, by the agency of Pepsine, the coagulated Albumen, Fibrine, Caseine, etc., are all transformed into one and the same substance, *Albuminose* (or *Peptone*,) which, unlike them, is readily absorbed, and is neither precipitated by acid nor by heat.

Starch is itself one of this class. Tiedemann and Gmelin found that by the action of the gastric juice it was slowly converted into Dextrine, which afterwards changed into grape-sugar. Both of these are very soluble. From the researches of Bouchardat and others, it appears that other fluids, as the Saliva, the secretion of Brunner's glands, and the Pancreatic juice, possess also this power of converting starch into a more soluble compound. And whereas it is found that a free acid hinders its transformation, and an alkali assists it, we must, I think, ascribe the chief part of this work to the Ptyaline of the Saliva and Pancreatic fluid, a principle analogous to the Diastase of vegetables. (Mialhe, *op. cit.*)

Thus the nitrogenous principles are digested in the stomach, and starch is probably reduced to solution and absorbed in the small intestine.

This change of starch is the first of a series of transformations, now ascertained, the ultimate result of which is its combustion and resolution into carbonic acid. Thus the nitrogenous compounds are called the *nutritive*, and the starchy materials the *calorifacient* elements of the food. Considered as medicines, these substances belong to the division of Aliments.

6. We have already considered some few mineral substances which are absorbed by the aid of the free alkali contained in the Biliary and Pancreatic secretions. The sixth kind of absorbed matters consists of some vegetable and animal products which can only be rendered soluble by a similar agency.*

* Liebig (*Anim. Chemistry*, part i. p. 76) states that the Bile contains Carbonate of Soda. So also does Lehmann (*Physiolog. Chem.* vol. ii.) That the Pancreatic juice is alkaline, was first stated by M. Bernard, and has since been abundantly confirmed by Schmidt and others. (*Brit. and For. Med. Chir. Review*, 1856, *p.* 227.)

Fats and oils, resinous matters, and some principles resembling resins, come under this head. Fats and fixed oils consist of acids, as Stearic, Margaric, and Oleic, insoluble in water, in combination with a base, Glycerine, which, when isolated, is soluble. With a free alkali such a fat forms a soluble salt, called a soap, and the base Glycerine is set free.

In Man the Bile and Pancreatic juice are discharged together in the middle of the Duodenum. The fatty matters of the food are not absorbed before they meet with these secretions. But, after they have mixed with them, a milky fluid called Chyle is formed, which is then taken up by the lacteal absorbents. It passes thence into the thoracic duct, meeting there with an albuminous lymph, and is discharged at length into the general circulation at the junction of the left jugular and subclavian veins.

M. Bernard, in some papers laid before the French Academy, stated, as the result of his experiments, that the function of the Pancreatic juice was to reduce the fat to the condition of a white emulsion. He found that no milky Chyle was formed when the Pancreatic ducts were tied in dogs. He considered it absolutely necessary that saccharine and albuminous matters should be absorbed by the capillaries of the Portal veins, and then pass through the liver; and believed that the sole function of the lacteals was to take up fat thus emulsified. His experiments and inferences received the high sanction of the late M. Magendie.*

M. Frerichs has since affirmed that, whatever be the function of the Pancreatic juice, the Bile, by virtue of the alkali which it contains, is an indispensable agent in the absorption of fats. But M. Bernard has also found that the Pancreatic juice is always alkaline in health.

* The emulsifying action of the Pancreatic juice has been disputed by Frerichs, Schmidt, Bidder, Donders, and others.

Whatever be the particular function of the Bile,* it may reasonably be concluded that the alkali contained in one or both of these fluids is engaged in the saponification and solution of the fatty and oily matters, which perhaps are first emulsified. If it were not for this, this alkali would seem without an object; and further, it is contrary to all we know of the process of absorption to suppose that oil could pass through to a watery fluid without the intervention of an alkali to reduce it to the soluble state.†

Thus it would seem likely that by means of the Pancreatic juice, with or without the aid of the Bile, fatty matters are first emulsified, in order to undergo an increase of surface, and then again saponified before they can be absorbed by the lacteal villi.

The principal fixed oils which are used in medicine are Castor, Olive, Almond, Croton, and Cod oils. It is certainly to be regarded as a very beautiful arrangement in the animal economy, that those substances which are not acted upon by an acid fluid should be subsequently subjected to the action of a free alkali, so that by the successive action of these solvents, together with the peculiar process of stomach digestion, the great majority of substances taken into the system are dissolved and rendered fit for absorption.

There seem to be other vegetable substances which are ren-

* Lehmann considers that the Bile at least participates in fatty digestion. For Bidder and Schmidt found that tying the Pancreatic ducts of animals did not prevent the injection of the lacteals with white chyle; on the other hand, when a biliary fistula was established in dogs, two and a half times less fat entered their systems than before.

† Here I may adduce the opinion of two high authorities on the subject of absorption:—"Il est certain que l'absorption (des matières grasses) ne saurait physiquement avoir lieu si les parois des intestins n'étaient pas baignées par un liquide avec lequel les corps gras auraient de l'affinité."—(*Matteucci, Leçons sur les phénomènes physiques des corps vivants*, p. 104 *et seq.*) "Aussi croyons-nous fermement que c'est aux bases alkalines contenues dans les sucs digestifs intestinaux que l'absorption des matières grasses doit être uniquement rapportée."—(*Mialhe, Chimie appliquée*, p. 189.)

dered soluble by means of alkali in the way already described. Resins form an important class of remedial agents, in which are comprised many Diuretics, Diaphoretics, and Purgatives. They consist chemically of peculiar acids, which, though themselves insoluble in water, combine with alkalies to form salts which are soluble. They are certainly in most cases absorbed. They have been found in the blood, and detected when passing out in the urine. (See Prop. I., and Eliminatives.) From this last they may be precipitated by an acid, indicating that they are held in solution by an alkali. In large doses they may not be absorbed, but, by irritating the surface of the intestinal canal, may act externally as Cathartics, and be expelled by the peristaltic action which they excite. But in small doses they enter the circulation in solution, and affect remote organs. The only way in which they can be dissolved is by means of the alkali of the two intestinal fluids.* Among resinous medicines I may mention Myrrh, Mastic, Benzoin, Storax, Peru and Tolu, Copaiba, Guaiacum, the fetid resins, etc. Many purgative drugs, as Jalap, Scammony, and Gamboge, owe their efficacy to resin.

There are, moreover, certain neutral acrid principles, similar in their nature to resins, which are soluble only in alkalies, and thus come under this head. Such are Cantharidin, Piperin, Pyrethrin, Colocynthin, Elaterin, and Capsicin, ob-

* From this we learn a fact which is useful in practice, *i. e.* that such resinous medicines may be often beneficially combined by the prescriber with a solution of a free alkali, or its carbonate. Acids oppose their operation; but when given with an alkali, they may be reduced at once to a state of perfect solution, in which condition they will act with more certainty, and in smaller doses than such as are usually given. Rhubarb has been suspected to owe all or a part of its efficacy to a resin, and it is certain that it may sometimes be administered with great advantage in the form of an alkaline infusion. A resinous cathartic, if given dissolved in an alkali, will be less likely to irritate the mucous membrane, because enabled to flow freely over a larger surface.

tained from Cantharides, Pepper, Pyrethrum, Colocynth, Elaterium and Capsicum. But it should be observed that some of these are soluble in Acetic acid; and if, as some have supposed, this acid exists in the gastric juice, then they might be dissolved in the stomach.

We may add here some medicines which were enumerated also in a former division. Creosote, not very soluble in water, is easily dissolved in a free alkali. This substance also, like the last, is soluble in Acetic acid.

Some volatile oils, especially Turpentine, display a marked tendency to oxidize into resins; and being themselves very sparingly soluble in water, may perhaps be dissolved after having undergone this change. Thus Turpentine changes into common Resin, which consists of two isomeric acids, Pinic and Sylvic.

$$\text{Turpentine} = C_{20}\,H_{16}.$$
$$\text{Pinic Acid} = C_{20}\,H_{15}\,O_2.$$

and,

$$C_{20}\,H_{16} + 3\,O = C_{20}\,H_{15}\,O_2 + HO,$$

or, Oil of Turpentine, with the addition of three atoms of Oxygen, produces Pinic Acid, *i.e.* Resin, and an atom of water.

Turpentine, when given in large quantities, irritates the surface of the intestinal canal in man, and is not absorbed. But in the horse very large doses are found to pass through the system into the urine. It is not likely that a large quantity should enter in solution in water. It seems more probable that it may first in some way become oxidized, and then dissolved as a resin. The action of turpentine resembles that of some other substances which contain resin, as Copaiba and Balsam of Peru.

The resins thus dissolved would pass, like other solutions, through the mucous membrane of the intestines into the Portal capillaries.

But of the fats and fixed oils it cannot be said to be *proved* that they are absorbed in a state of solution, although such a conclusion is almost forced upon us by a consideration of the laws of endosmosis. They do not pass into the veins, but are taken up by the lacteal absorbents. They are *capable of solution*, and are thus not in that sense an exception to the rule of Prop. II. But in another sense they are an exception to it; for they do not pass directly into the veins, but through the lacteal system. It seems that the chief or sole purpose of these lacteal vessels is to absorb fats.

Thus it appears that all soluble substances, whether in the food or given as medicine, and in whatever manner rendered soluble, whether by acid, by alkali, or by a process of digestion, are absorbed in the stomach and intestines. All of them, with the exception of fatty matters, pass directly into the blood, traversing the mesenteric and Portal veins, to reach the liver. From this organ they pass on into the heart through the vena cava inferior. I have shown also that they are mostly absorbed without material change. Some mineral salts may enter into combination with albumen. The stomach lactic acid would be too weak to displace mineral acids. It would, however, decompose a few insoluble matters, and combine with alkalies and their carbonates, forming salts which in the blood would again change into carbonates. (*Vide* Prop. VI.)

PROP. III.—*That those medicines which are completely insoluble in water, and in the gastric and intestinal juices, cannot gain entrance into the circulation.**

It may at first sight be objected to this proposition, that fatty matters may enter the lacteals in an undissolved state. But this is not proved; and besides, whether dissolved or not, we know that they are soluble in one at least of the intestinal juices—viz. the Bile. So that they do not come under the above definition.

We have just seen that many medicines which are given in the insoluble form are capable of being dissolved in the fluids of the intestinal canal. This so much reduces the list of perfectly insoluble medicines, that it is difficult to find any that come under such a definition. But Charcoal, the simple metals, woody fibre, and Nitrate of Bismuth, will serve as examples.

Sulphate of Lead is often quoted as perfectly insoluble; but this is not the case. It is dissolved by alkaline chlorides. It is soluble in a solution of acetate of ammonia. These salts are contained in the perspiration. Thus the sulphate, when substituted for the carbonate, in some lead-works at Paris, proved fatal to the foreman, who died of colic. M. Flandin found that it poisoned a dog when rubbed into the skin as ointment. Even some metals may possibly be brought within the influence of weak acids when in a fine state of subdivision, as Mercury, in blue-pill. Gold, in a very fine powder, has been used successfully in syphilis.

Thus the list of insoluble substances is still further reduced. But there is no doubt that many substances which are slightly soluble in the intestinal fluids may in great part escape this solution, and pass out with the fæces just as they went in.

* "The remedy must be soluble, or capable of becoming so, in the fluids of the living body, before it can be absorbed."—*Mialhe, L'Art de Formuler.*

To assert that the particles of an insoluble substance cannot pass through the homogeneous wall of the capillary or absorbent vessels, is merely to state what follows from an absolute physical law, and is generally admitted by physiologists.* But even this fundamental datum has been lately attacked.

Professor Œsterlen, of Dorpat, has been induced to affirm the possibility of the absorption of insoluble substances, from some experiments which he has made. Finely powdered charcoal was administered to rabbits for some days. They were then killed, and globules of charcoal, measuring from $\frac{1}{6000}$ to $\frac{1}{3000}$ of an inch, were found in the blood of the Portal circulation when examined by the microscope.† (*Zeitschrift für Rationelle Medizin*, 1847.) Œsterlen reasonably concludes that, if charcoal can so pass, so also can any other insoluble substance. The necessity of solution could then at once be

* Dr. A. Fleming, in an article in the 'British and Foreign Medical Review,' quotes Matteucci as stating that the interstices of the animal tissues vary in diameter from $\frac{1}{2540}$ to $\frac{1}{5080}$ of an inch. He then asks, What is to prevent minute particles of charcoal from passing through such openings? Surely there is here some terrible mistake! Matteucci is speaking of such interstices as those between muscular fibres, or in the meshes of areolar tissue,—and the reviewer applies the statement to the membrane through which the absorbed particles must pass. This is well known to all physiologists as homogeneous or basement membrane. I need hardly remind the reader that no apertures whatever can be discovered in this membrane, even by the highest power of the compound microscope. So that unless this membrane underwent some lesion or injury, no particle *large enough to be seen* through such a microscope could pass through it without being first dissolved. But every substance absorbed in the intestinal canal must pass through at least two layers of this membrane one belonging to the mucous coat, the other constituting the delicate wall of the capillary vessel. (Epithelial cells which exhibit perforations have been lately spoken of by Kölliker and Virchow, as existing on the surface of the villi of the small intestine. Should this be confirmed, it yet in no way accounts for the passage of solid matters beyond these cells, and through a homogeneous imperforate membrane.)

† It will be observed that the largest of these are just equal to the average size of the corpuscles of the blood. So if the particles of charcoal passed into the vessels, why did not the blood corpuscles pass out? Vessels having walls pierced with such apertures as to allow of the entrance of these bodies, would probably permit of copious and continual hemorrhage. For it is well known that blood corpuscles will pass readily, by undergoing compression, through passages of much less diameter than themselves.

done away with, and the blood continually liable to admixture with all kinds of heterogeneous and crude materials. Œsterlen asserts further that he has found minute globules of mercury under the skin after rubbing in mercurial ointment. (*Journal für Praktische Chem.*, No. IX. 1850.) Now, if these things were true, there could be no need to suppose the solution of insoluble active medicines, for they would be enabled without difficulty to pass through in an undissolved state.

I have therefore repeated the above-mentioned experiment of Œsterlen, taking every precaution that I could think of to guard against a fallacy.

Half a pound of highly purified and finely powdered animal charcoal was triturated for some time with water, in order still further to increase the tenuity of the particles. Some of this paste being then examined under the microscope, and the particles carefully measured with the spider-web micrometer, their size was found to average $\frac{1}{20000}$ of an inch, some being much smaller, others larger. This charcoal paste was now administered, in divided portions, during seven successive days, to three rabbits and a guinea-pig, being mixed up with the pollard which was given to them as food. At the end of this time no morbid or other symptom having been observed, except the carbonaceous character of the fæces, they were killed by Prussic acid. On opening them, a blackening of the inner surface of the stomach and intestines was the only peculiar appearance noticed. Specimens of the fresh blood of each were then successively examined under the microscope, the blood being taken from the right cavities of the heart, the Portal and mesenteric veins, and the inferior venæ cavæ. An eighth of an inch object glass was used. In the majority of cases nothing at all was seen except the blood corpuscles. But in about one out of four observations first made, some amorphous black particles were perceived, the appearance of which was at first dubious. They were very few in number—only one or two among myriads of blood corpuscles—and they would not have been noticed at all had it not been for the peculiarity of the investigation. Their size at once excited suspicion, some of them measuring six times the diameter of a blood corpuscle ($\frac{1}{500}$ of an inch.) In fact, they were found to be minute particles of dust, and they were only got rid of by the most assiduous attention to the cleaning and protection of the glasses in subsequent observations. Besides these, there was now and then seen an amorphous molecule of hæmatine, such as is known to occur occasionally in healthy blood, especially that of the splenic and Portal veins. Such particles are known by their partial translucency, and the possession of a yellowish or brownish colour.

I thus saw no appearance which could be at all compared with the observations of Œsterlen, who describes particles of charcoal as occurring in abundance in blood drawn from each of the four sources just mentioned.

To test in another way the accuracy of the above observations, I killed two cats, which had been for some time fed upon milk, at King's College. I then examined their blood in the same way. I found, in several instances, the same solitary hæmatine globules, and experienced the same difficulty as before in getting rid of stray particles of dust. It is quite clear that in animals fed on milk, these latter could have had no connexion whatever with the passage of charcoal from the intestinal canal into the blood.

It may still be asked of me how I would explain the recorded observations of Œsterlen. It is very likely that they are not altogether inaccurate. It has occurred to me that they may possibly be accounted for by supposing that in the animals which he fed upon charcoal, the irritation might have been sufficient to establish some minute points of ulceration by means of which there would be a communication between the intestine and the cavity of the vessel, sufficient to allow of the passage of the carbonaceous particles, without permitting any notable hemorrhage (though this last is difficult to believe.) Thus, in the black phthisis of colliers, it is supposed by some pathologists that the sooty matters inhaled find their way into the blood through ulcerations in the walls of the air cells.

["It has been supposed," says Valentin, "that blood corpuscles, or particles of Indigo or finely powdered charcoal can pass directly through (the basement membrane.) But more exact observations militate against this notion. We can easily imagine that very small and angular pieces of charcoal may be accidentally driven into the blood-vessels under the influence of the pressure furnished by the intestine, and may then be washed off by the circulating blood. But the process is essentially exceptional, and affords no support (clue?) to ordinary absorption."—*Text-book of Physiology*, translated by Brinton, *p.* 157.]

A precipitate of Prussian Blue, so fine that it will not deposit from the water when it is allowed to stand, may be considered an instance of a solid body in the very extremest state of subdivision conceivable. Its particles are infinitely smaller than those gross atoms of charcoal experimented on by Œsterlen. Dr. Beale has made use of such a precipitate mixed with water, and appearing as a dark blue liquid, for injecting the smaller ducts of the liver, which have very thin walls. He states that though the precipitate is so fine that it may be mistaken for a solution, the minute particles cannot be made to pass through the basement membrane of the ducts. (*Beale on the Liver*, 1856, *p.* 7.)

A year after the publication of the second edition of the essay which recorded the above experiments, M. Mialhe announced that he and Soubeiran, in Paris, had arrived at the same results. M. Bérard had made trial of wood soot, with a similar negative result, opposed to that of Œsterlen. Mialhe supposes it just possible that the more angular particles of wood charcoal may effect an entrance in the manner suggested above. "It is probable then even supposing that M. Œsterlen had not suffered himself to be misled by an illusion—yet that this was in no wise a phenomenon of absorption, for the sharp and angular molecules of charcoal may have mechanically frayed a passage through the soft substance of the villi." (*Chimie appliquée*, 1856, *p*. 197.)

Moleschott has taken up this controversy on the other side. His results are said to be similar to those of Œsterlen, but they have again been repeatedly and amply negatived by Bidder, Schmidt, and Donders.

With regard to the other alleged discovery of globules of mercury beneath the skin after the rubbing-in of mercurial ointment, it may be stated that another experimenter, Dr. Bœrensprung, has repeatedly made trial of this, but has never discovered any such globules. (*Journ. für Prakt. Chem.* IX. 1850.) It is also opposed to the experiments of Autenrieth and Zeller, who, first causing the skin of an animal to cicatrize over a plate of gold, and then rubbing mercurial ointment over this, found afterwards that the surface of the gold was untarnished. (Had any metallic mercury penetrated so far, the gold would have been whitened by amalgamation.)

I may here also add some experiments, which I made some time since, with the object of discovering whether some of the most insoluble of known remedies, which are yet known to obtain entry somehow into the blood, could do so while yet in the insoluble state. They are as follows:—

Exp. 1.—Ten grains of Calomel were given to a large dog. It was killed after three hours, allowing this time for digestion. A considerable quantity of blood was collected from the Portal vein, and submitted to analysis, to determine whether it contained any compound of Mercury in an insoluble form. The blood was dried and pulverized. The result was boiled for some time in water, and the insoluble part collected. It was dissolved in a small quantity of aqua regia, and the clear acid solution placed in a test-tube. A slip of zinc foil was folded round a narrow plate made of gold foil, and introduced into the solution. A galvanic current being thus set up, the minutest quantity of mercury if present would have been deposited on the gold, so as to tarnish it. But this did not take place, and when at last the zinc was completely dissolved, the gold remained as bright as before. There was no Calomel, or compound of mercury, present in the insoluble form.

Exp. 2.—Ten grains of strong mercurial ointment (containing half its weight of metallic mercury, with some oxide) were given to another dog. He was killed after the same time, and the Portal blood analyzed carefully in the same way, but here also no mercurial compound was present in the insoluble form.

Exp. 3.—To a third dog five grains of Oxide of Silver were administered. After three hours he was killed. The Portal blood was dried in a water-bath and reduced to powder. This was boiled for some time in water, which was separated by filtration. Aqua regia was then boiled on the insoluble part. This would convert any silver into chloride. The acid was evaporated off as much as possible, and the solid remainder heated in a small porcelain crucible to dull redness. The result was powdered, and digested in liquor ammoniæ. It was filtered, and excess of nitric acid was added. There was not any precipitate. Had chloride of silver been present, it would have been dissolved by the ammonia, and precipitated by the acid. Thus no insoluble silver compound was contained in the blood analyzed.

Exp. 4.—Ten grains of sulphur were administered in the same way to a fourth dog. On killing it and opening the body, the thoracic duct was found to be full. A considerable quantity of chyle was collected from it. Now, as it is asserted by some, that fat passes undissolved into the chyle, and as I believe that sulphur is digested in the neighbourhood of the bile duct, this chyle was chosen for analysis. Besides, the blood would be less satisfactory, on account of the large quantity of albumen and fibrine contained in it, both of them also containing sulphur. The insoluble part of the chyle was obtained in the same manner as with the blood. It was then boiled in a small quantity of a weak solution of caustic potash. By this any free sulphur would be converted into a soluble sulphuret of Potassium. The solution was filtered, and a few drops of a solution of the Nitro-prusside of Potassium added. (This is a salt lately discovered by Dr. Playfair. It is a delicate test for soluble sulphurets, with which it strikes a deep purple colour.) No change was produced. Therefore no insoluble sulphur was present in the chyle.

The results of these various experiments are thus in decided opposition to those of M. Œsterlen, and support a view of the question which seems even *à priori* more philosophical and reasonable than that which he has adopted. I believe that no insoluble medicine can in any way gain entry into the blood without first undergoing solution in some way or another.

PROP. IV.—*That some few remedial agents act locally on the mucous surface, either before absorption, or without being absorbed at all. That they are chiefly as follows:—*

A. Irritant Emetics.

B. Irritant Cathartics.

C. Superficial Stimulants, Sedatives, Astringents.

Though it has now to be shown that some medicines may act without being absorbed, yet as these operate on the surface only of the stomach and intestine, it must be borne in mind that they are no exception to the Rule of Absorption, and that no medicines whatever can exert their proper action on distant parts without being first absorbed into the system. For it has already been declared, during the consideration of the first Proposition, that medicines which thus act on remote parts of the body must be, and are, absorbed before they can so act. This necessity for absorption has been shown to extend even to medicines which act most rapidly on the nervous system. If any medicines could produce a distant effect by a mere contact with the coats of the stomach, such a power would be ascribed to those stimulants and sedatives which, from the suddenness of their action, are called diffusible. Such are Hydrocyanic Acid and Ammonia. Their rapidity of action is to be ascribed to their volatility, whereby they spread over a large surface, and are almost *suddenly* absorbed and transmitted through the system. But Hydrocyanic acid may be absorbed from any surface. It is poisonous when inhaled into the lungs. It rapidly causes death when dropped into the eye of an animal. So also the results of the inhalation of Ammoniacal gas are the same as those which follow the ingestion of its solution. I believe that the latter, on account of its diffusibility and rapid absorption, escapes neutralization by the stomach acid, and passes into the blood as free Ammonia.

In the consideration of the first Proposition, I endeavoured also to point out that though the proper action of a medicine could in no case be conducted, without absorption, from the mucous surface to a distant part of the system, yet a remote action of another kind might occur, as the result of a change in the nervous system produced by a powerful local impression. I stated that the term *Counter-Irritation* was employed to express this action, the nature of it being but ill understood. A powerful impression on any surface of the body, external or internal, seems to be capable of arresting and diverting, as it were, the attention of the system, and thus, for a time, of checking a morbid process. Frictions and Sinapisms act on the skin externally on this principle. So do Blisters and Issues; but they are not simply counter-irritants, for they also drain away the serum of the blood. It is not now within my province to consider such an action on the skin, any further than for the purpose of stating that similar local impressions on the mucous surface of the stomach and intestines are capable of operating on the same principle.

We have then to consider what are the local actions that medicines are capable of producing on these surfaces.

And first it must be laid down as a rule, that all medicines, when given in excess, act as irritants on the stomach and intestines. This is more especially the case with mineral salts, with the bitter and astringent principles of vegetables, and with acrid and resinous matters. By irritating the stomach locally, they cause vomiting; by causing peristaltic action of the bowels, purging. Some of them are actually employed to produce these effects, and will be presently specified.

The corrosive and narcotico-acrid poisons may produce by this local action a degree of irritation sufficient to cause death. In the case of the first, some erosion of the mucous surface may occur. By both kinds violent vomiting and purging is apt to be produced, and succeeded by symptoms of collapse.

These last, however, are not *therapeutic* agents, when in such doses.

Antidotes, employed to counteract these poisons, are remedies which are given to act locally in extraordinary cases. There are three chief kinds of them; Demulcents, to sheath the irritated surface, and protect it from further injury; Emetics and Purgatives, to get rid of the poison; and Chemical antidotes, to neutralize it or render it insoluble while in the stomach. With this last object, acids are given in alkaline, and alkalies in acid poisoning. The soluble salts of Lead may be precipitated and rendered insoluble by sulphuric acid or sulphates. Those of Mercury, Copper, and Zinc by albumen. Tannic acid precipitates the vegetable alkaloids. There are some other special antidotes of the same kind.*

Let us now briefly consider the remedial agents in ordinary use, which are employed for the purpose of producing a local effect on the mucous surfaces, before absorption, or without absorption.

A. Irritant Emetics.—Two kinds of medicines are employed to produce Vomiting,—specific emetics and irritant emetics. The former act from the blood; the latter by local irritation.† In the same way that irritation of the external surface of the body will sometimes cause at the same time the *direct* contraction of a neighbouring muscle, and the *reflex* contraction of others at a distance, so does local irritation operate on the surface of the stomach. On the one hand, the muscle of the stomach itself is caused to contract, so that, the pylorus being

* Thus Sulphites of Potash and Soda have been recommended by Professor Graham and others to destroy the *Sarcina ventriculi* and the supposed *Cholera fungi.* Quassia and bitters have also been given with the intention of poisoning such parasitic vegetable productions.

† *Irritation*, i. e., a violent dynamical action on nerve and muscle, differing both from the healthy agency of a stimulant, and the chemical operation of an astringent medicine.

at the same time forcibly closed, it tends to expel its contents in the wrong direction. On the other hand, a large set of distant muscles is thrown into sudden action. First, a quick deep breath is taken by means of the inspiratory muscles. Then the aperture of the glottis is spasmodically closed, so that, the lungs being full, the diaphragm cannot be pushed upwards. Then immediately the abdominal muscles contract, and being unable to act on the diaphragm, they press on the stomach, emptying it forcibly of its contents.

All this is by reflex action, and follows sympathetically the contraction of the stomach, co-operating with it, and resulting, like it, from irritation of the sensitive mucous surface.* Such is the action of an irritant emetic. (See p. 71, *note.*)

Tartar Emetic and Ipecacuanha do not act in this way. When injected into the blood elsewhere, in sufficient quantity, they are found to produce vomiting. They have also special actions on the heart and lungs, which are not possessed by merely irritant emetics. They seem to me to act specifically on the Vagus Nerve, which is supplied to these organs as well as to the stomach, and to cause vomiting by deranging its functions. By this action on the Vagus while in the blood, they excite, in a special way, the same reflex contractions which are produced, in the case of an irritant emetic, by irritation of the extremity of that nerve in the mucous membrane. They are thus Neurotics, or nerve-medicines. They are not gland-medicines; or, at least, there is no proof that they are excreted by the stomach, and thus they do not come under my definition of Eliminatives. All substances which touch the surface of the stomach cause it to pour out its secretion.

Specific emetics cause nausea, even without vomiting, de-

* Occasionally, as in certain cases of Pyrosis, slight vomiting may take place without any straining effort of this kind, but apparently from the contraction of the stomach alone.

pressing the action of the heart by their influence over the Vagus nerve. Irritant emetics scarcely cause nausea, producing only a feeling of discomfort, arising from the inverted action of the stomach.

The Sulphates of Zinc and of Copper, common Salt, and among vegetables, Mustard and Horse-radish, are used as irritant emetics. They cause, by contact and irritation, a large quantity of the gastric juice to be poured out. This, together with the emetic, and any contents of the stomach, is rejected. The process is not followed by much inconvenience.

Such emetics are chiefly used when we wish to unload the stomach of any irritating or poisonous matters; but not when our object is to cause nausea, depression of the heart's action, or relaxation of the muscles. The violent action which they produce may possibly act on remote parts on the principle of counter-irritation. Thus emetics of various kinds are often administered in the early stage of inflammatory disorders, and have been known sometimes to cut them short. But such an effect is much more likely to be produced by a specific emetic, which adds to this counter-irritant action the production of nausea, by which the force of the heart is powerfully depressed, and the pulse reduced. Tartar Emetic, the most powerful of these specific agents, must doubtless be absorbed to a certain extent before it can produce its effect. Thus the important difference between the modes of operation of irritant and specific emetics is, that the former do not produce vomiting when injected into the blood, but act locally; whereas the latter act from the blood on the nerves. (*Vide* Prop. VIII., *Special Sedatives.*)

That Tartar Emetic acts from the blood may be proved in various ways. It was established long ago by Willis. He found that the injection of some antimonial wine into the jugular vein of a large dog was followed in about six minutes by strong efforts at vomiting. (*Pharmaceut. Rational., part* 1, *sec.* 2, *cap.* 1, *pp.* 54, 55, *edit. Haganæ.*) Or, if the œsophagus of an animal be tied above the cardia, and a solution of this salt introduced into it, efforts at vomiting follow. Such specific emetics must either act upon the Vagus nerve itself, or, which is much the same thing, on that part of the nervous centre with which this nerve is connected,—the medulla oblongata. Whereas it seems that the merely irritant emetics have the power of at once stimulating the ultimate fibres of the Vagus which are distributed to the stomach. But as it will be stated directly that some irritant purgatives are also, after their absorption, specific purgatives, so is it still a matter of doubt whether some of these irritant emetics may not be also capable of acting from the blood as specific emetics.

This may be said especially of the Sulphates of Zinc and Copper. Dr. Maclagan made some experiments upon them several years ago. He found that section of both nervi vagi deferred the action of these two salts until long after the time at which they had previously operated on the same animals with these nerves uncut. This sustains the view already expressed, of their operation by irritating the ultimate filaments of this nerve. But as in one instance the emetic dose did ultimately act after the section, the experimenter reasonably infers that this can hardly be explained but by supposing the absorption of the salt and its subsequent operation on that part of the medulla where the vagus takes its rise, from which an action might then be reflected along the motor fibres. But the sources of fallacy in such inquiries are so many, and our knowledge of the anatomical relations of the Vagus so imperfect, that we cannot found any positive statement on the result of this experiment.

Some other Sedatives, and Narcotics, as Tobacco and Lobelia, act physiologically as specific emetics, but are seldom or never used as such. Vomiting has been caused in children by simply washing the skin with infusion of tobacco, to cure them of Scabies. (*Boerhaave, op. cit., p.* 227.)

B. Irritant Cathartics.—As there are two kinds of Emetics, differing in their mode of operation, so also do there seem to be two kinds of Cathartics. But the distinction between them is not exactly the same. As with the Emetics, one kind seem to act by topical irritation, exciting an outpouring of the intestinal secretions, and causing an expulsion of the contents by exciting peristaltic contraction. But Specific Emetics, which act from the blood, seem to produce their effect by influencing the nerve of the stomach; so that they are Neurotic medicines. Specific Cathartics act differently.

They are truly Eliminatives. They exert no influence over nerves, but they operate by passing out of the blood through the intestinal glands. Like Specific Emetics, they must be first absorbed. But whereas the chief action of an Emetic is to excite contraction, that of a Cathartic is to increase secretion, by which contraction may result as a secondary effect. I will not now enter into the theory of Elimination, which I shall have to consider afterwards, but I wish at present to distinguish between local action on a surface, and specific action on a gland, exerted from the blood. Many substances used as purgatives are capable of absorption, and are absorbed. But it seems that they are not fit to remain in the blood; and after passing round in the circulation, they are expelled by the depurative force at a point near to that at which they previously entered by the laws of absorption, namely, the mucous surface of the bowels. They are most commonly expelled by the glands of this surface somewhere in the lower or fecal portion of the intestinal canal, which is more engaged in secretion, but less active in absorption, than the upper part. The increased secretion which they excite causes peristaltic action, which expels both it and them, so that they cannot again be absorbed.

Such a specific Cathartic would be capable of acting thus, if introduced into the system at any point. Castor Oil and Croton Oil, whether received into the stomach, or injected into the veins, or introduced into the system at any part, equally produce purging. So also do Rhubarb, Aloes, and Senna. The principles of these medicines have been detected in the blood by Tiedemann, Gmelin, and others. Colocynth and Elaterium have also been proved to act specifically.*

It is to be inferred, both from analogy and direct experi-

* Pereira's Materia Medica, 2nd edit. vol. ii. pp. 1496, 1507, and elsewhere. See also above, p. 65.

ment, that other resinous Cathartics, as Jalap, Scammony, and Gamboge, act also from the blood. It has also been shown that both from actual experiment, and from a consideration of the laws of the process of absorption, we must conclude that saline Cathartics are absorbed into the blood before they cause purging.

But we have now to do with Cathartics that act by topical irritation. Which are they? I believe that the same resinous Cathartics which have the power of acting specifically, may have, especially when in large doses, a double action. It has been shown that resins are difficult of absorption; and whether they be absorbed or not, we know that they must irritate the intestinal surface, from the violent griping which often attends their operation. Thus Scammony does not act so well, and does not gripe, when the bowels are lined with mucus. Gamboge and Euphorbium are irritant in an extreme degree, and are therefore too dangerous for general use. The powder of Euphorbium resin has been used as an Errhine, for, by irritating the mucous membrane of the nose, it increases its secretion. This illustrates the operation of irritant Cathartics. A great part of the fæces is secreted by the mucous membrane of the bowel. This secretion a Cathartic may increase by mere contact and irritation; or, being also a specific agent, by absorption and elimination likewise.*

Some Cathartics employed as Vermifuges, as the hairs of *Mucuna pruriens*, metallic Mercury, and Tin powder, cannot be absorbed at all, and must act solely and altogether by irritation.

* Irritant Cathartics, like irritant emetics, may sometimes affect remote parts on the principle of counter-irritation. Some explain in this way the use of purgatives in disorders of the brain, but there are other reasons which seem to account for this still more satisfactorily. (*Vide* Chap. IV., art. *Purgatives.*)

These Vermifuges, or Anthelmintics, are employed for a strictly local purpose—that of killing and expelling intestinal worms. Any powerful Cathartic may be used to expel them. But such an agent should generally be conjoined with a medicine that tends directly to kill the parasite; for after that it will be more easily dislodged. For this purpose the root of Male Fern, Kousso, and the bark of the root of Pomegranate, have been used with advantage in the case of tape-worm. Ascarides are situated low down in the intestine, and may be dislodged by the use of an enema, as of Salt.

Turpentine is often very efficacious in cases of this kind, being at once a poison to the worms and a powerful irritant cathartic.

C. Neurotics and Astringents which act on the mucous membrane in transitu.—It is apparent that many of those medicines which tend to pass by absorption into the blood, and thus to act on the system at large, may at first, as far as they are capable of so doing, exert a topical action on the mucous membrane which they have to traverse. This, like the skin, is supplied with superficial nerves, which may be functionally excited by a stimulant, depressed by a sedative drug. Such an action is very transient, as the agent which causes it is on its passage elsewhere. Moreover, the muscular fibre which forms so integral a part of these membranes, as well as of the glandular ducts with which they are plentifully sown, may be constringed and made to contract by an astringent medicine.

Of the great number of agents which may act locally in this way, there are but few which exert any marked influence, or which require notice here. We may arrange them under three divisions: Muco-Stimulants, Muco-Sedatives, Muco-Astringents.

C. 1. *Muco-Stimulants.*—The volatile oils and pungent principles of the spices and aromatic vegetables are employed for their local action on the mucous membranes, under the names of Cordials, Carminatives, etc. Alcoholic drinks, and Ammonia, exert the same stimulant action in a higher degree.

In indigestion, arising from a flaccid and atonic state of the coat of the stomach; in flatulence and colic, depending on a similar weakness and want of energy of the mucous membrane of the intestines, a cordial, by stimulating at one and the same time the motor and sensory fibrils distributed on either surface, may promote a healthy reaction.* Such a medicine, too, may be used to correct the griping tendency of an irritant cathartic, or even to check diarrhœa when depending on a want of tone. Wine, Cinnamon, Cardamom, Nutmeg, Ginger, are examples of such agents. They should not be used when there is any condition approaching to inflammation, as acting on a susceptible surface they tend to irritate. (See *note.*)

C. 2. *Muco-Sedatives.*—There is a class of medicines used in Gastrodynia which seem to act locally on the sentient nerves or surface of the stomach (and, more rarely, of the bowels) in the same way as Aconite acts on the superficial nerves of the skin, or a plaster protects from irritation a painful ulcer. Although the majority of them are subsequently absorbed, yet, in order to exert this particular action, it is not necessary that these should pass beyond the substance of the stomach itself. For the anodynes thus used do not seem to have any special or peculiar tendencies towards the stomach nerves. But if introduced into the blood elsewhere they would not pass the nerves of the stomach in so concentrated a form as when coming directly from the mouth, and thus would not be so useful as stomach-anæsthetics. Thus this action depends upon local contact, and is so far a local action.

Hydrocyanic acid, Creosote, and Nitrate of Bismuth, are the most useful of the medicines which control pain in the stomach. Of these three, two only are strictly sedatives, the

* Such stimulation, when carried to a point that cannot be borne, becomes *irritation.* The agent then causes vomiting or purging, according to the mucous surface on which it acts. Irritant emetics and irritant cathartics, on account of their special importance and peculiarity of action (which is strictly local,) have been already separately considered. It may be observed that many irritants are in no case stimulants. (See *note*, p. 107.)

other is a mechanical agent. The first two are subsequently absorbed, and pass into the blood.

Hydrocyanic acid and Creosote are general sedatives, and act locally as anæsthetics or anodynes to the nerves of the stomach. Opium, and other anodynes, may operate in the same manner. As these medicines are rapidly absorbed from the stomach, when used in painful affections of the bowels they can only act from the blood. Opium, the best anodyne in intestinal affections, probably operates in this way, as its beneficial influence is coincident with its other effects on the system at large.

The Nitrate of Bismuth is a very insoluble salt. It passes down along the mucous surface of the intestine, and is not absorbed. Being insoluble, its action is quite confined to the mucous surface. It may be given safely in very large doses (as ʒj., or more,) and it is probable that its anæsthetic action is simply mechanical in nature, and depends upon its affording a soothing sheath to the irritable and painful surface of the stomach. So that it is only by covering this, and not at all by an influence on the stomach nerves, that it operates as a local anæsthetic. In the bowel also it sheathes the surface, and absorbs irritating fluids. It is not a true astringent, and counteracts certain forms of diarrhœa in something the same manner as chalk.

Monneret also believes its action to be purely local. So do Trousseau and Pidoux. Monneret has given as much as ℥j. daily, without ill effects. Lussanna likewise has prescribed large doses, but he considers that a part is absorbed, being rendered soluble by the acid fluid of the stomach. It is just possible that this might occur in some conditions of the system, and peculiar states of the gastric secretion; but I think even this very improbable. It covers the coat of the stomach, and hinders the excretion of gastric juice. And all the cachectic symptoms described by this writer as having followed its long use may be explained by this obstruction to the digestive process. A strong argument against its absorption is derived from the fact that it can never be discovered in the urine. Lussanna accounts for this by supposing that as soon as it enters the blood, the Bismuth is precipitated by the alkaline chlorides in that fluid, and thus, being rendered insoluble, is incapable of excretion. But what would become of the patient if precipitations were thus to take place in his blood!—(*Gazetta Medica Italiana Federativa Toscana*, 1852, *p.* 44.)

Orfila believed in the absorption of Bismuth, but his results are probably explained by his having made use of the ternitrate, instead of the insoluble salt of which we are speaking. Mialhe is of opinion that the latter, though dissolved (?) by the acid liquid of the stomach, is again decomposed by alkaline fluids in the mucous tissue before it can be absorbed.

C. 3. *Muco-Astringents.*—In a lax condition of mucous membrane, with a tendency to profuse secretion, a cordial or stimulant may do good indirectly by exciting the nerves, which re-act on the muscular fibre, causing it to contract. But an astringent medicine, while traversing the gastric or intestinal membrane, may operate directly on the muscular fibre itself, so as to produce this contraction. (See Astringents.) A topical astringent, as Alum, Sulphate of Copper, Acetate of Lead,* Nitrate of Silver, or Tannin in the astringent vegetables, may check a profuse secretion from the stomach (Pyrosis,) or an excessive flux from the intestine (Diarrhœa,) because its action on muscle diminishes at the same time the calibre of the bowel itself, and the calibre of each muscle-girt gland-orifice through which this secretion is poured out. As is the case with the stimulants and sedatives above mentioned, so with these astringents: their local action here coincides in all respects with their action at other parts of the body after absorption. They conform precisely to the rule of the Fifth Proposition; they reach the part on which they operate. That part is now the mucous surface with which they first come in contact. It might seem that they should act here more powerfully than anywhere else. But it is by no means always so. There are two things which prevent it. Inasmuch as this surface is by its position accus-

* The prolonged use of lead causes a condition the reverse of constriction, *i. e.* paralysis of the muscular fibre.

tomed to bear with comparative insensibility all variety of impressions; by reason also that these agents are on their passage towards the blood, and do not remain here, it follows that they frequently produce less effect on the mucous membrane than on those distant parts at which they arrive in but small quantity. Yet, of course, when taken by the mouth, they produce a greater impression on this particular surface than they would if introduced into the system otherwise.

I have already alluded to Nitrate of Bismuth, as acting as a quasi-astringent to the mucous surface of the intestine, although apparently incapable of absorption. It has been used with advantage in diarrhœa, and is highly recommended by Dr. Theophilus Thompson in the diarrhœa of Phthisis. It absorbs acrid fluids, and protects the irritable surface. Chalk is useful in diarrhœa in the same way, but adds to the above operation a power of neutralizing acidity.

All true neurotics and astringents, being soluble, are absorbed; and when they act on the mucous glands of the intestines, may of course do so otherwise than by local contact from without, reaching them from the blood without having passed down along the mucous tract beyond the stomach.

It has been supposed by M. Poisseuille and others that the action of Opium in confining the bowels is to be attributed to a power of checking the process of endosmosis, said to be possessed by a solution of Morphia. I shall afterwards state my reasons for discrediting this explanation. (*v. Chap. IV. Art. Opium.*)

Thus we have concluded the list of substances which seem to act locally on the mucous surface, without passing into the blood.

Having previously endeavoured to explain the various modes in which medicines are absorbed and pass into the blood, and having now defined the action of some few before absorption, the greater part of our investigation remains still to be accomplished. The actions of medicines in the blood, and their various and complicated operations in the cure of diseases, have to be traced out, and, if possible, accounted for.

The remaining six Propositions concern the behaviour of medicines after their passage into the blood. The first two of them are comparatively unimportant. The Fifth is merely an extension of the First Proposition,—in which the same rule is applied to the blood which was there proved of a surface,—and indeed follows in part from the latter. The Sixth Proposition defines three kinds of changes which certain medicines are liable to undergo during their stay in the system.

PROP. V.—*That the medicine, when in the blood, must permeate the mass of the circulation, so far as may be required to reach the parts on which it tends to act.*

That there are two possible exceptions to this rule:—

a. The production of sensation or pain at a distant point.

b. The production of muscular contraction at a distant point.

We might already have concluded that, as a general rule, it is impossible for medicines to exert their primary action on a remote part by nervous or any other agency, but that they must actually reach the part which they affect, by means of the circulation. The experiments, already quoted, of Magendie, Blake, and others, show that even those medicines and poisons which tend most powerfully to influence the nervous centres, cannot act by nervous connexion, or without being allowed to pass on in the blood. They must actually reach the brain, before they can act upon it. The circulation of the blood is sufficiently quick to allow of this.

The action of nerve-medicines when applied to a part, being similar to that which follows their absorption, would alone render it highly probable that in the latter case they reached the part in the blood. Thus Morphia, Hydrocyanic acid, Chloroform, and Aconite, benumb the superficial nerves; Belladonna dilates the pupil; and Strychnia augments muscular irritability, whether locally applied, or administered through the stomach.

Neurotic medicines have even been detected after death in the parts and organs which they influence. Thus Alcohol has been found in the brain, and Lead in the spinal cord and muscles.

From these various facts we may conclude, that however near these remedies may be brought to that part of the nervous system over which their power extends, whether it be centre or periphery, they do not in general affect it, unless they are allowed to reach it.

And what is proved of nerve-medicines holds good still more obviously with medicines that act on the blood, and on blood-disorders. Nearly all of these have been found to exist in the blood, and to pervade the whole mass of the circulation wherever at first introduced.

The glands of the body form a third case in which we require proof of actual local access. This matter will be discussed when we have to consider the subject of Eliminative Medicines, when I shall attempt to show that the majority of those medicines actually pass through and are excreted by the glands which they affect. When Mercury is chemically detected in the secretions of the liver and bowels; Sulphur in that of the skin; Turpentine and Copaiba in that of the kidneys; it is evident that these substances must have reached bodily the glandular organs to which their action is directed.

Astringents are medicines which from the very nature of their action—apparently a chemical one—cannot operate at all without touching the muscular fibre, which they cause to become contracted.

But in laying down this rule of the necessity of local access for the production of the primary * effect of a medicine, we must be careful that we do not make it too absolute. No

* The process of cure by *counter-irritation* may be ascribed to the *secondary* action of some medicines. Such an operation may take place at a distance from the part affected; but it is attributable to a peculiar affection of the nervous system, and has no necessary connection with the primary or proper action of a medicine. (*Vide* p. 71.)

proper medicinal action can be conducted along a nerve-fibre. But in saying that *no action at all* can be propagated by the agency of the nervous system, we do not make proper allowance for the vital properties of nerves. The vital nature of common nerve-fibre is such that two actions can be conducted along it;—an impulse producing sensation, or an impulse producing muscular action, at a distant point. It is known that an impression on the terminal extremity of a sensory nerve is capable of producing either sensation or motion at a distance, by what is called *reflex nervous action*. Though this impression must pass through the brain or spinal cord, yet these centres are not appreciably affected by it. Now it is possible, though it does not often happen, that the action of a medicine on the extremity of a nerve may cause this distant action, without that medicine reaching the part at which it is manifested. It is obvious too that such a medicine as Strychnia may cause contractions of muscles at a distance from the brain and spinal cord, by stimulating those centres. Here the *proper action* is on the centre; it is this nervous centre that stimulates the muscles, not the medicine.

Having made allowance for the physiological characters of nerve, we must also take notice of the vital properties of muscular fibre. We sometimes find, especially in the case of unstriped muscle, that when one part of a muscular organ is caused to contract, a wave of contraction is propagated along the fibres; and this action may even be extended to a neighbouring muscle, either by contact or sympathy. In one or two cases it seems that muscular contraction may occur in this way as the result of the action of a medicine.

We will now consider separately the two exceptional cases.

a. A medicine may occasionally produce pain or sensation at a distant part, without reaching that part. We often find that a morbid action at one part of the body is capable of producing pain or uneasiness at another distant part by a reflex nervous action. We are familiar with instances of this among the symptoms of disease. The pain in the knee which occurs in disease of the hip-joint; in the left arm, in some cases of heart disease; and in the right shoulder, in disorders of the liver, are examples. Certain impressions on the surface of the stomach may cause such a reflex pain. Swallowing a piece of ice will sometimes produce pain over the brow; and it is likely that the headache which follows over-eating, or a large dose of a tonic medicine, may result in a similar way from mere irritation of the stomach. Any irritant, as a solution of Iron, Arsenic, or Zinc, will do the same. The action of a violent purgative will cause headache while it lasts. Although we cannot deny the possibility of other actions of the same kind, yet there are so few medicines which, in ordinary and safe doses, are capable of producing pain in any way, that it becomes difficult or impossible to adduce a satisfactory example of an agent which operates on distant parts in this manner when in the blood.

b. A medicine may occasionally produce muscular contraction at a distant part, without reaching that part. This may be done in two ways; either by a nervous action, or by a propagation of the contraction from one muscle to another in its neighbourhood. Of the first we have a good example in the convulsive contractions produced by the action of Strychnia on the nervous centres. It may also follow an impression on a surface. Thus we have already seen that the irritation of the mucous membrane of the stomach, and probably of the filaments of the Vagus nerve distributed in it, which precedes the act of vomiting, may cause the contraction of the muscles of the abdomen.

The propagation of contraction from one muscular organ to another appears to take place in the case of violent purgatives, particularly some, as Aloes and Savine, which act on the lowest portion of the large intestine, exciting it to a peristaltic contraction,—whose action may thus be extended to the contiguous Uterus in the female, causing it also to contract. This renders the employment of such medicines dangerous in cases of pregnancy, as tending to produce abortion. In other cases these agents may be useful; for by the irritation and congestion which follows this action on the Uterus, they may cause the appearance of the menstrual secretion when deficient or retained. This also is the result of an action on a surface.

Now, though in such cases the action of a medicine seems to be continued from the part where it is situated to a distant point, there are altogether but few examples of such an action by a remedy in the blood. Yet, though it is not reasonable to deny the possibility of such a thing, such instances are certainly rare, and, being cases of the manifestation of their vital properties by nerve and muscle, rather than of the proper action of a medicine, must not be considered to invalidate the above Proposition, which, as a general rule, is of considerable importance.

PROP. VI.—*That while in the blood, the medicine may undergo change, which in some cases may, in others may not, affect its influence. That these changes may be—*

a. Of Combination.

b. Of Reconstruction.

*c. Of Decomposition.**

Before advancing to the consideration of the modes in which medicines operate in the cure of disease, it is of importance to mention that some of them are liable to undergo changes in the animal organism, because in particular cases

* "Most remedies are subject to chemical changes during their passage through the animal system. These changes are regulated by ordinary chemical laws, they may therefore be foretold, and even made available in the cure of disease."—*Mialhe, L'Art de Formuler.*

these changes may materially affect their action, and in all cases they have some bearing upon it. With a view to this point I have divided these changes, somewhat arbitrarily, into three kinds,—of which the first does not hinder the effect of a medicine—the second may alter it slightly—and the third entirely changes or neutralizes it. Some of these changes have to be considered more at length in the progress of the Essay, so that here I will only give an outline of them.

Changes of combination.—The chief, and indeed almost the only way of detecting changes in medicines, is by taking notice of their effect upon the composition of the secretions.

Now in the blood we have a slight excess of alkali; in the urine, an excess of acid. Acids and alkalies are often given as medicines; and as it is not right that there should be much excess of either in the blood, both are generally soon neutralized in the system, and reduced to salts. This may sometimes occur before absorption, but perhaps more often after it. Now, it may seem strange for me to say that this neutralization does not destroy their influence. But it really does not; for in being neutralized they diminish in the blood, and in the system generally, the quantity of basic or of acid matter, and thus tend to alter the reaction of the secretions. Though an acid may combine in the blood with Soda, or with salts of Soda, yet by so doing it causes an excess of some other acid, probably an animal acid, which, being set free, acts on the secretion of urine much in the same way that the first acid would have done. (It is easier to render the urine alkaline than to make it acid, for two reasons; first, as I shall show hereafter, an acid may pass out through other glands besides the kidneys; and secondly, an alkali is not so easily neutralized, either before or after absorption, the blood being already more or less alkaline. Or, granting that an alkali when in the stomach may combine with lactic acid, the lactate afterwards becomes oxidized in the blood, and a carbonate passes into the urine.)

A large quantity of acid would easily overcome the feeble reaction of the blood, and thus, by remaining free, Sulphuric and other acids are enabled to act as astringents on certain of the glands.

Other changes of combination have already been shown to take place during the process of absorption. Weak acids may be set free from their salts by the acid of the gastric juice, as Hydrocyanic acid is liberated from Cyanides, on which account they are so poisonous. Alkalies and their carbonates are more or less neutralized by the stomach acid. Substances soluble in alkalies are probably absorbed in such solution. Phosphorus, under the influence of the intestinal alkali, combines with the elements of water to form hypophosphorous acid and phosphuretted hydrogen. In the same manner, Sulphur becomes absorbed as a sulphuret and hyposulphite, and Arsenious acid as an arsenite of an alkaline base. Iodine passes out in the urine as Iodide of Sodium. Calomel, Chalk, Magnesia, and metallic oxides, as well as other insoluble medicines, are taken up in the soluble form, in which only they are capable of acting.

But we are now concerned with medicines in the blood. In this fluid there must occur certain reactions between the albumen and salts of the natural blood on the one hand, and the medicine now introduced on the other. Processes are here completed which may have commenced, or been partially accomplished, in the interval preceding or during the act of absorption. (See page 79.) Metallic salts may undergo precipitation with albumen, but the albuminate is again reduced to solution by the alkaline blood. (By the intervention of some such reaction, the oxides of the metals escape being thrown down in the insoluble form by this alkali.) The salts of Silver, Mercury, Lead, which are precipitated by an alkaline chloride, are probably again dissolved by the agency of an excess of such salt existing in the blood. Mialhe considers that this formation of a soluble double chloride takes place before absorption, but I do not think that the chlorides of the intestinal fluids are in sufficient amount to carry out such a proceeding, (page 88.) And even these statements as to the chemical actions of the blood must be for the most part conjectural. We do not know how far the vital forces, as well as the viscidity of the plasma, may exert a retarding or controlling power over such chemical tendencies.

Some substances are recombined while passing out of the body. Decomposing matters, in the intestines and in the saliva, cause the formation of Sulphuret of Iron while chalybeates are taken, which blackens the fæces;* and of Sulphuret of Lead, when lead is taken for some time, producing the well known blue line on the gums.

Changes of Reconstruction.—The elements of a body may be disturbed in the system, and combined together anew, without any material or apparent alteration of its properties. Probably many changes of this kind occur, but only some isolated instances have been verified. Thus Tannic acid, acquiring Oxygen, changes into Gallic. Benzoic and Cinnamic acids are converted into Hippuric acid, which passes out in the urine. Turpentine changes into a volatile oil, which communicates to the urine an odour of violets. Ferridcyanide of Potassium changes in the system into Ferrocyanide. Some of these changes will be afterwards considered more at length.

Changes of Decomposition.—By this I mean such a disarrangement of elements as shall neutralize or reverse the action of a medicine.

There is free Oxygen in the blood, and the most important change to which all organic substances are liable there is *oxidation.*

This probably occurs in many cases. It always takes place

* The use of Bismuth in large doses causes blackening of the fæces in the same way.—*Lussanna, Gazetta Med. Italiana Fed. Toscana,* 1852.

with the starchy elements of the food, and with those parts of the nitrogenous tissues that have done their work, and are preparing to be excreted from the body. These latter pass out in the renal secretion in the form of Urea, Uric acid, etc. If re-introduced into the system, Urea again passes out unaltered into the urine, but Uric acid is still further oxidized, forming Urea and Oxalic acid, the latter being excreted in combination with Lime.*

Carbonated drinks also cause an increase of Oxalate of Lime in the urine, part of the free Carbonic acid being oxidized into Oxalic acid. Some mineral compounds undergo oxidation in the system; as Sulphuret of Potassium, which passes into the urine as Sulphate. This probably happens also to many organic principles. For example, Salicine changes in the blood into Hydruret of Salicyle, which, like so many other substances similarly produced, passes out in the urinary secretion.† Hydruret of Benzyle (an odorous principle which forms the bulk of the essential oil of bitter almonds) is changed into Hippuric acid.‡

By this oxidation Wöhler has proved that the salts of the alkalies with vegetable acids are changed in the blood into alkaline carbonates. From being first neutral, they become now alkaline in their reaction, and affect the urine in the same way as free alkalies.

(*Vide Hæmatica, ord. Acida, Alkalia, Tonica, Solventia.*)

We have now to treat of the actions of medicines in the blood. These are recited in the four remaining Propositions.

* See *Lehmann's Physiological Chemistry*, vol. ii., art. *Urine.*

† This product has an agreeable odour, and is identical with the Oil of Meadow-sweet. It may be similarly formed in other animal systems. Thus Liebig finds that the *Chrysomeli Populi*, an insect which feeds on the leaves of the willow and poplar, excretes Hydruret of Salicyle. (See also *Pereira on Aqua Castorei*, Pharm. Jour. xi. p. 200.)

‡ An observation made severally by Wöhler and Frerichs, and confirmed by Dr. Maclagan, during a course of experiments in which he proved this oil to be comparatively innocuous. As soon as the commercial oil is freed from the prussic acid which it contains, it may be used without risk.

The seventh treats of Hæmatics, acting primarily in the blood.

The eighth treats of Neurotics, passing from the blood to the nerves.

The ninth, of Astringents, passing to muscular fibre.

The tenth and last treats of Eliminatives, which pass out of the body through the glands.

PROP. VII.—*That a first class of medicines, called* HÆMATICS, *act while in the blood which they influence. That their action is permanent.*

1. *That of these, some, called* RESTORATIVES, *act by supplying, or causing to be supplied, a material wanting, and may remain in the blood.*
2. *That others, called* CATALYTICS, *act so as to counteract a morbid material or process, and must pass out of the body.*

Supposing that a medicine has fairly passed into the blood, and circulates round with it, there are now two ways in which it may behave itself.

In the first place it may have a tendency towards some tissues or parts of the body, on which to exert its powers, as the nerves, or the glands, or muscular fibre, and may use the blood only as a vehicle by which most readily and easily to attain to these. Such are Neurotics, Astringents, and Eliminatives. They may not affect the blood, but they must pass through it.

But there is another and still more important class of medicines, whose action is particularly directed towards the blood itself. The blood, after their action, is different from what it was before. It may be a change for the better or for the worse; but there certainly is a change. Medical authors, with few exceptions, have been very backward to acknowledge the existence of medicines of this description.

But even those who would fain have classed all medicines as stimulants or sedatives, differing only in the kind or degree of their action on the nervous system, have in many cases been obliged to confess that there is a set of remedies which they call 'Alteratives,' whose action, though slower, is more certain and more durable than that of the former. It is allowed that they alter the condition of the blood. To suppose that they do so by first influencing the nerves, is to adopt a circuitous and uncalled-for explanation. It is proved that they pass into the blood. It is known that when actually applied to nerves they do not affect them. From these considerations merely, without further evidence, it would seem tolerably clear that they act by influencing the blood itself, simply and solely. But this it will be my business to prove more at length directly.

Such medicines, then, I have designated Hæmatics, a simple and expressive term which has been used by others before me.

Considered as agents in the hands of the practical physician, Hæmatics may be said to differ from the three other classes of medicines in two important particulars. (1.) They act on the blood, and on the system generally. They therefore are of use to control or cure *diseases*, in which usually the system is at fault, and not a part of it only. But the others act on certain parts of the system, and are directed against certain conditions of those parts. They control *symptoms*. (2.) The medicinal action of Hæmatics is chiefly shown in morbid conditions of the blood, or system at large. It is not evidenced upon a healthy man. The only exception to this occurs in the case of Aliments, or articles of food, the first order of Restorative Hæmatics. And even this exception is rather apparent than real, for in fact Hunger and Decay must be considered as diseases, and food as medicine given to cure them. Hæmatics then do not evidence their proper action on a healthy man. But remedies of the three other classes, producing changes or affections of particular organs or parts of the body, and not absolutely requiring a diseased condition of the organ before such changes can be effected, do accordingly exert their action upon a healthy man. I have already alluded to this action on the nervous system as being named by most writers *Physiological action*. It is *Therapeutical action*, or operation on a diseased system, which is most borne in view in my arrangement. It is altogether of most importance to us. For if we desire to cure disease, we must consider medicines as acting on disease. Having first discovered their therapeutical principle of action, then is our time to speak of their operation on the healthy body, and to inquire how far this working resembles or coincides with the former. And we shall then find, as I have just said, that the physiological and therapeutical actions of Hæmatics are different. Given to a healthy man, they are either inoperative or poisonous. That which in a small dose is *remedium* to the sick, may have to be given in a large dose to be *venenum* to the healthy. Thus Acids and Alkalies, given in small doses to a healthy man, produce little or no effect; given in larger doses, they cause wasting; whereas Arsenic, Mercury, and the Catalytics generally, are always more or less poisonous in a healthy system. But suppose the existence of certain diseased conditions, and the case is changed. The alkali is required to neutralize an abnormal acidity; and the Mercury counteracts in the blood the syphilitic poison. So that the therapeutical use of Hæmatics differs from their physiological action, inasmuch as it demands the pre-existence of some special condition of the system. But with the three other classes the case is different. Although their action is doubtless much modified by particular states of the organs, yet they act similarly on the nerves, muscular fibre, and glands, whether these are in a state of health or the contrary. Opium will stupefy the brain, and Digitalis weaken the heart, as well in healthy as in diseased systems. The therapeutic use of Neurotics, Astringents, and Eliminatives, is not to counteract blood diseases, but local symptoms; to control morbid affections of the various organs, by their power to produce affections of an opposite character.

It is obviously necessary that a medicine of this class should be absorbed.

Now some of them tend in the end to act on the nerves or on the glands, not merely indirectly, but by bodily contact. But, whatever their subsequent action, they exert a primary and apparent influence on the blood itself. A little reflection will convince us that these remedies are more efficient than any others that can be selected out of the armoury of physic.

It is easy, and satisfactory for the time, to allay nervous excitement by employing a sedative, or by using a stimulant to communicate to the system a temporary strength. It is easy to knock down an inflammation, or to evacuate morbid humours, by stirring up the glands with a powerful eliminative. But these are all at the best but temporary measures.

Unless the exigency be also of a temporary character, the disorder may soon return with unabated violence; again is the patient bowed down by its strong hand; again is the fatal termination seen looming in the distance but too distinctly. Then has the physician to call to his aid more potent means, remedies of more permanent and certain efficacy. The disease is in the blood—ever circulating, breeding, and destroying. It is there that it must be met; let the physician strike boldly and warily there, if he would effect a cure.

These medicines, then, act in the blood. How they do so, and in what way they prove of use in the cure of disease, I shall next have to show, while attempting to prove the proposition in which I have briefly stated this mode of operation.

Hæmatics are very numerous, and very important: I shall thus devote some space to their considerations. But I must first lay down a broad distinction between the two divisions of Hæmatic medicines. The diseases in which they are used appear all to originate in the blood, however they may manifest themselves.

Now some of these diseases originate in a want of some principle or constituent of the blood, which want causes an aberration of the vital functions.

Thus, in anæmia, there is a deficiency of the Hæmatosin of the blood corpuscles. In simple debility a want of a similar nature probably exists. In rheumatic fever and other disorders an excess of acid is formed and eliminated, possibly from a want of the alkali by which it should be neutralized. In common inflammatory fever there is an abnormal oxidation of the Proteinaceous compounds, possibly connected, as we shall see hereafter, with some failure in the supply of the principles which are the proper food of the oxygen. In diseases causing urinary deposits there is a want of those principles which should naturally retain them in solution. In typhoid fever there is said to be an excess of basic matter, and a deficiency of acid, in the blood. In pulmonary phthisis there is a deficiency of fat in the system. In the latter stage of malignant cholera there is an absence of watery particles in the blood. Some suppose that in scurvy there is a want of the salts of Potash in the blood.

These diseases, then, in some of which the want is proved, in others partly hypothetical, may be treated by medicines which supply the deficient matter, and thus restore a right state of things. They may supply it to the blood directly, or else cause it to be generated there. The former of these modes of restoration seems to be the most frequent, and may possibly, when we shall know more of such matters, be found to occur, in all cases. This division of Hæmatics I have named Restoratives (Restaurantia.) Their action, as we shall see, is in some cases apparent, in others more obscure. They restore the blood directly to its proper condition, if there is only a deficiency, but they do not in general seem to have the power of counteracting any morbid or active material that may exist in the blood. Nor do they, except in large doses, exert themselves any peculiar action on that fluid. In these respects they differ from the other division of Hæmatics. They also differ in another important character. Each Restorative has in healthy blood a substance analogous to or identical with itself: it replaces this when deficient.

Not so with other Hæmatics. There is in general nothing in the blood corresponding to them—or if there be in some cases, they are not introduced with the intention of supplying its want. Thus restoratives may remain in the system, and are intended so to do; but these may not remain. They must pass out. In so doing they come under the head of Eliminatives, or that of Astringents. This is their secondary action, distinct from their primary and most important operation. What then is the curative action of these remedies?

A large class of diseases depends on the presence in the blood of a morbid material, or, what amounts to the same thing, on the constant working of a morbid process in that fluid. Some of these, as the eruptive fevers, will run a certain course, and then come to an end. These we cannot generally stop, but can only alleviate. But others, more in number, and more commonly met with, tend naturally to run on for an indefinite period, unless by any means we can arrest their progress. Some depend on a contagious virus, communicable from one person to another, as Syphilis. Some, as Ague, are dependent on atmospheric or terrestrial influences. Others are due to some derangement of the secondary assimilative processes, as Scrofula, Scurvy, Gout, and Rheumatism. Others again, to causes that are ill understood, as convulsive disorders and skin diseases. Lastly, some may be caused in many different ways, as common inflammatory fever.

Now the object in the treatment of such diseases is to obtain in each case some remedy that shall be able to counteract this process, something that shall destroy the morbid influence at work, and thus restore health. Medicines that are used with this intention form the second division of Hæmatics, which I have named Catalytics (Catalytica,) from a Greek verb, signifying to destroy or to unbind.

Now though I have a probable hypothesis to advance as to the action of some of these, I would not have this considered as more than hypothetical. I would not speak positively of the action of any one of them, any more than to say that each of them tends to neutralize one or more particular morbid poisons.

Some have tried to give a general explanation of their action, and have talked of it as if it were easily understood by their known properties. I am not of their opinion; and when I speak of Catalytics, I shall give my reasons for disagreeing with them. Now each Catalytic has peculiarities and affinities that distinguish it from all others. I have not thought that I could arrange them more truthfully than by subdividing them according to the diseases which they tend to counteract. How inadequately is the action of Mercury and of Iodine expressed by calling them special stimulants, alteratives, or absorbents! Is it not better and more correct to say at once that Mercury is useful in checking inflammation in general, and in counteracting the poison of Syphilis in particular? and that Iodine is effective in secondary forms of the latter disorder, as well as in Scrofula?

These medicines, then, are specifics, in so far as they are particularly useful in certain disorders, and in those excel other remedies; but they are not, in the vulgar acceptation of that term, the only medicines which can be employed in such a disease, nor is their use to be restricted to it alone. I have already said that a Catalytic tends of itself to work out a peculiar process in the blood. For this reason their administration in health generally does harm. They have nothing in the blood corresponding to them; or if so, they are not introduced to supply its want. Thus they must eventually pass out of the body. Before doing so, some may act on the nerves. While so passing out, they may, as I have said, act either as Astringents or Eliminatives on the glands. Under these heads their secondary action will be subsequently considered.

Being thus foreign to the blood, Catalytics do not remain there to supply a want, but just long enough to counteract a morbid action, after which operation they should be excreted.

Such is the difference between Restorative and Catalytic medicines. Although so far as this their action is sufficiently distinct, yet some care is required in separating the remedies in one division from those in the other. Sometimes both kinds are used in the same disorder. For whenever the action of a morbid poison causes any derangement in the proportion of the normal constituents of the blood, a Restorative may become of use to supply this defect. Thus a cancerous or scrofulous condition may cause a deficiency in the red colouring matter of the blood, which may be supplied by Iron. When, as in Gout and Rheumatism, there is an excess of acid in the system, partly due to an absence of that basic matter which should be present to neutralize it, this may be restored by an alkaline remedy. In both of these cases a Restorative may be used in a disease which depends on a morbid agency. But other remedies, Catalytic in their action, are of more direct use in such disorders. They counteract the original poison, and, striking at the root of the evil, instead of correcting the consequences, they are more likly to eradicate the disease.

Some medicines come under both heads, acting in different ways in different cases. Thus Potash may be a Restorative in Rheumatism, or a Catalytic in Scrofula.

The operation of some particular agents is rather obscure. I shall have to show how it seems to me that the vegetable acids may act as Restoratives in fevers; and also to explain why, of those medicines which are used in Intermittents, I have placed Quina among Restoratives, and Arsenic with Catalytics.

It may be remarked that the fact that Catalytic medicines produce of themselves distinct actions in the blood has proved a stumbling-block to the disciples of M. Hahnemann. For in some few cases their action may, to a certain extent, simulate the disease which they tend to cure, and has thus been confounded with it by this imaginative observer. This partial resemblance is probably due to the fact that both disease and remedy produce a series of changes in the same set of particles in the blood. If it were not so, the remedy could not meet the disease. It would be out of its province, as not acting at all in the same sphere. But that the actions are essentially different is sufficiently proved by the fact that they counteract each other. The remedy, moreover, is often of equal efficacy in other different disorders. It has been shown in Chapter II. that with regard to Eliminative medicines the Homœopathic theory is founded on a misapprehension of facts.

It must not be inferred, from what has been said on the importance of blood-medicines, that I am disposed to agree with those who would account for all diseases by some fault in the humours of the body. For though we know that many cases of convulsive disorder, as of Hysteria, Chorea, and Epilepsy, may be reasonably accounted for by supposing the existence of a wrong in the blood, which has affected the nervous system,—yet there are doubtless also many nervous affections which are primarily independent of the blood, which can only be treated by Neurotic medicines, and even then often without benefit.

Thus far I have chiefly dealt in assertions on the subject of Hæmatic medicines, but I am now about to attempt a thing which is more difficult, *i. e.* positive proof.

I shall treat separately of Restoratives and Catalytics; each division will be divided into certain distinct orders of medicines; and of each of these orders in turn I shall attempt to prove what is laid down concisely in Proposition VII. To simplify this proof, that part of the Proposition which relates to Restoratives will be divided first into a number of minor propositions, which, taken together, imply the original one. Each must be shortly proved applicable to each order of Restoratives. The same will be subsequently done with Catalytics. Having sustained the original proposition to my own satisfaction, I shall, in some cases, venture to offer an additional hypothesis—only as hypothetical—on the action of particular medicines.

Let us now proceed to the consideration of the first division of Hæmatic medicines.

RESTORATIVES.

The general name given to the medicines in this division is founded upon a fact relative to their action, which will be acknowledged of most that I have here included—namely, that they restore to the blood certain materials in which it is deficient.*

I will divide them into six Orders, which are all distinct and characteristic in their mode of action.

RESTAURANTIA.

Ord. 1. Alimenta.
Ord. 2. Acida.
Ord. 3. Alkalia.
Ord. 4. Tonica.
Ord. 5. Chalybeata.
Ord. 6. Solventia.

On reverting to Proposition VII., which treats of the action of the first class of medicines, it will be seen that what

*It has been already stated that the details of this arrangement are founded upon the *therapeutic operation* of medicines, as used to cure diseases, and not upon their *physiological action* on a healthy man. Much unnecessary confusion in works on Materia Medica, has arisen from these two different matters being taken into account at the same time. Food is the only restoration of wanting material needful to a healthy man; neither is there in such a case any need or opportunity for the counteraction of morbid agencies.

"Medicines," says Dr. Paris, "are for the most part but relative agents, producing their effects in reference only to the state of the living frame. We must therefore concur with Sir Gilbert Blane, in stating that the virtues of medicines cannot be fairly essayed, nor beneficially ascertained, by trying their effects on sound subjects, because that peculiar morbid condition does not exist, which they may be exclusively calculated to remove."—*Pharmacologia*, 9th edition, 1843, p. 133.

Professor Albers, of Bonn, in his late work on the Action of Medicines, determined to adopt their operation in the cure of diseases as the text of his essay. "Es ist die pathologische Grundlage, welche für die Prüfungder Arzneiwirkung und Anwendung hier in Anspruch genommen wird. Die Wirkung der Arznei im Gesunden, in Thierin, des ganze chemische Verhalten derselben sind für jene nur Erläuterungs-lehren, die noch keineswegs an sich schon die Anzeige für den Gebrauch in Krankheiten ergeben." (Preface, p. iv.)

has been there stated with respect to the action of Restoratives resolves itself into the following simple affirmations, or minor propositions.

m. p. 1.—That they act in the blood, and that their effect is permanent.

m. p. 2.—That there are naturally in the blood substances which resemble or coincide with them.

m. p. 3.—That they are not of necessity excreted, but may remain in the blood.

m. p. 4.—That they are of use when a disease depends on the want of one or more materials in the blood.

It will be seen that the first minor proposition affirms them to be Hæmatic medicines, according to the definition given before. The second is required; for if there were not a necessity in the blood for substances like them, they could supply nothing. The third also is necessary, for if they were excreted in all cases, it is evident that their Restorative action could not be lasting. An exception must be made in the case of those that are used to supply something which is necessary in order that a secretion may be properly elaborated. Medicines of the Sixth Order are particularly used with this intent; as also some acids and alkalies. But these are not repugnant to the blood, like Catalytics. In the fourth place it is affirmed that being thus fitted for the blood, and allowed to remain in it, Restoratives tend to cure a disease which depends on the want of a substance similar in nature to themselves.

After giving a brief account of each of the orders of Restoratives, it will be my object to prove that these affirmations are severally applicable to each of them.

ORD. I. ALIMENTS.

This order comprises all substances which are naturally required by the animal body, to supply growth, to repair waste, and to maintain the various functions at the healthy standard.

An article of food is the simplest form, and in fact the type, of all medicines of this division. Out of the materials of the food the whole blood is constantly elaborated, and all the tissues are constructed.

Aliments were divided by Dr. Prout into four kinds:—(1) Aqueous; (2) Albuminous; (3) Saccharine; (4) Oleaginous. These kinds differ much in chemical conformation. The second kind alone contain Nitrogen. The last two are both called *carbonaceous;* but those of the fourth kind contain more Carbon than those of the third. The following will serve to illustrate the differences in the chemical composition of these groups:—

1. Water $= H\ O.$
2. Proteine $= C_{40}\ H_{31}\ N_5\ O_{12}.$
3. Starch $= C_{12}\ H_{10}\ O_{10}.$
4. Stearic Acid $= C_{68}\ H_{68}\ O_7.$

Water is useful in dissolving the other elements, and reducing them to a state of solution which is fitted for the formation of blood, and of the other fluids of the body. A certain amount of some diluent should be taken with every meal in order to assist the absorption of the solid parts of the food.

We have already seen in what way these various matters are dissolved and absorbed in the *primæ viæ,* and how they pass into the circulation; that Proteinaceous and Saccharine matters pass into the capillaries of the Portal vein, and thence onwards through the liver; and that Fatty matters are emulsified and dissolved by the alkaline intestinal juices, and pass through the lacteals into the thoracic duct, by which they are conducted into the circulation at large.

What then are the chief uses for which these matters are required in the system, and what great functions do they fulfil?

The nitrogenous Aliments are needed particularly to supply the growth and waste of the muscular and nervous tissues, which both contain Nitrogen; as also do all the parts of the body, excepting Fat. This waste is continually going on. It depends upon the fact that, after having lasted a certain time, the particles of all these tissues are gradually displaced, oxidized, and conveyed away out of the blood into the urine and other secretions. In the urine these waste matters are found as Urea, Uric acid, and Kreatine.

The starchy and saccharine parts of the food are destined to pass through a series of changes, which ends also in their being burnt and oxidized, maintaining the animal heat, and forming Carbonic acid. Starch passes first into grape-sugar (or Glucose,) by taking into itself two atoms of water, becoming $C_{12}\ H_{12}\ O_{12}$. The Ptyaline of Saliva, Pepsine of the gastric juice, and some similar principle in the Pancreatic fluid,* are all capable of causing this first transformation. This sugar is more soluble than starch; so that the starch of the food is found in the blood in the form of Glucose, which may be discovered chemically in that fluid, shortly after a meal on starchy matters. Dr. R. D. Thomson, who was one of the first to make this discovery, finds that when starch is merely mixed with fresh serum, it changes into this sugar in less than a quarter of an hour. (*Philosophical Magazine*, May, 1845.) And M. Figuier, in a paper read before the French Academy (Jan. 29, 1855,) states that he finds Glucose in small quantities to be a constant constituent of healthy blood. But while thus in the blood, this sugar undergoes a further change. This is into Lactic acid ($C_6\ H_5\ O_5$, $H\ O$,) whose equivalent number is just half that of anhydrous Glucose, so that one atom of the latter may become two of the former.

*See Krieger, '*Dissertatio de Succo Pancreatico*,' Dorpat, 1854. Also Mialhe, *Chimie Appliquée*, 1856.

This important compound was found by Berzelius, in 1807, to exist constantly in the juice of muscle, as well as in the urine and sweat. (*Annuaire*, 1848, p. 347.) Liebig at first controverted this, but in 1847 he assented to the statement of Berzelius, which had already been further confirmed by the experiments of M. Pelouze. Many modern chemists, among whom may be mentioned Dr. Bence Jones (*Animal Chemistry*, p. 20,) have long considered that Lactic acid, or some compound nearly resembling it, is formed at this step of the process of changes connected with the function of respiration. That it really is Lactic acid may now be considered as proved. The Glucose in diabetic urine allowed to stand will often develop spontaneously into this acid. The latter has been found in this urine by Dr. Gray, of Glasgow. (*Glasgow Med. Journal, Oct.* 1856.) And M. Bouchardat, though, like others, he finds sugar in the recent blood of Diabetics, states that after it has been suffered to stand for twenty-four hours, none can be found. He thinks it is then converted into Lactic acid. (*Du Diabète sucré, et son Traitement hygiénique*, 1852.) It is probably the arrest of this latter conversion (occurring in health) which constitutes Diabetes mellitus. Dr. F. W. Pavy conceives that particles of fibrine undergoing change or decay constitute the natural ferment which converts Glucose into Lactic acid. An acid state of blood is found to hinder this metamorphosis. (*Guy's Hosp. Reports, Third Series, vol. i.*, 1855.) The existence of Lactic acid in the sweat, as asserted by Berzelius, has been confirmed by Dr. Favre. (*Archives générales de Méd.*, 1853.)

The acid next combines with free Soda, existing in the blood; and this salt is oxidized into Carbonate of Soda and water, just as a Tartrate or a Citrate might be. (*Vide* p. 153.) This has been ascertained by Magnus and Dumas.

All other sugars (of cane, milk, etc.) are converted into Glucose, or grape sugar, before absorption. They may even sometimes undergo the further transformation into Lactic acid before quitting the intestine. For Lehmann finds that the ingestion of much sugar gives rise to an intensely acid reaction in the jejunum and ilium. This may interfere with the process of intestinal digestion, which requires alkalinity. For this reason an excess of sugar in the food is frequently prejudicial in dyspeptic and gouty disorders. It is not the mere production of Lactic acid, which ensues inevitably from all starchy* food,—it is its premature formation in the intestine which is hurtful.

Fatty matters are used in the production and renovation of the adipose tissues; and may also, like the last, be burnt and oxidized to support the animal heat.

As a general rule, the diet of a man in health should contain a due proportion of all four kinds of food; for each one of them is essential, and has its proper function in the system. The albuminous material cannot be dispensed with; and is also the only food which will suffice by itself to sustain life. The mode in which it can adapt itself to perform the office of the other varieties of food was ill understood, until explained by the researches of M. Bernard.

From some experiments detailed in a paper read before the Académie Française in 1848, he concluded that the liver was capable of actually producing sugar and fat out of Proteine compounds. For he found sugar to exist in the substance of the liver when none was to be detected in the blood of the Portal vein which proceeds to it. His results have been mainly confirmed by M. Lehmann. M. Bernard considers further, that the action of the liver is in some way essential to the assimilation of saccharine matters; for he has found that when sugar is injected into the veins, beyond the liver, it passes out unaltered in the urine.

Thus the process of assimilation, whether of albuminous or of saccharine matters, is not so easy and so simple a thing as might at first be imagined. The study of this process is of great importance, and it appears to afford us a clue to the causation of certain disorders of the blood, of which I shall have to speak hereafter. (See *Antiarthritics.*)

Upon the regulation of diet, one of the most important of

* And from animal food also, when starch is withheld. The Lactic acid must be produced somehow; so in this case, Glucose is formed out of the albumen by the agency of the liver. (Fat may be produced at the same time; or, by oxidation, Urea and Carbonic acid.) (See above.)

the duties that devolve upon the medical man, it is not my purpose to make more than a few observations.

All kinds of food are less required by the system in inflammatory and febrile disorders; and should then be administered sparingly, or wholly denied, according to the severity of the case. But in Typhus fever long abstinence would be dangerous; the patient is in peril from extreme weakness and inanition, and, being often totally unconscious of his natural wants, requires to be carefully sustained by constant and small increments of animal and farinaceous food.

Water may be given largely whenever we wish to increase the amount of any of the fluid secretions; as the urine, to render less likely the deposition of gravel; or the perspiration, when it is desirable to promote it in fevers or other disorders.

Albuminous food is always necessary in health, and is contained not only in the flesh of animals, but in vegetable substances in their natural condition. It is recommended to restrict it in the management of gouty or plethoric patients. On the other hand, animal is more easily digested than vegetable food in many cases of dyspepsia.

In Diabetes mellitus, when a large quantity of sugar is excreted in the urine, it is a common practice to confine the patient to a diet of meat and gluten bread. This latter is a tough horny material, prepared from flour, from which the starch has been separated by washing. It is thought that if no starch be given, no sugar can be formed; but it is found that though both the amount of urine and the quantity of sugar in it are diminished by this plan, yet the latter does not wholly disappear. This may be easily accounted for; as we admit that sugar may be formed from albumen. It is recommended that water should be given sparingly in this disease; for it is thought that the more a patient drinks, the more urine he passes, and all of the same high specific gravity. I am myself rather doubtful of this. At least I am sure that the restriction of water, if carried to such a point as to make the patient miserable, does more harm than good.

Fat may be given in Diabetes, for it is not proved that it can be converted into sugar; but as the contrary seems to be the case with albumen, and it being impossible to withhold this, the radical cure of the patient by mere dieting may be considered hopeless.*

Pepsine has been already noticed as an albuminoid substance secreted by the stomach, and concerned in the act of digestion. In some cases of dyspepsia the stomach seems to have partly lost this power of secreting a digestive ferment. In such cases, Pepsine obtained from the gastric juice of the lower animals may be supplied in small quantities with the food. It may be given in the liquid form as *Rennet* (obtained by macerating the stomach of the calf in salt and water.) M. Boudault recommends Pepsine in the solid form, mixed with dried starch.

We have seen that Starchy and saccharine matters form an important element of the food; and that, by combining in the blood with the Oxygen absorbed in the respiratory process, they are of use in maintaining the heat of the body. In some constitutions there is a peculiar tendency to an abnormal oxidation of these materials into Oxalic acid. It appears likely that all kinds of Sugar are liable to this change in the system. Thus the patient is sometimes benefited by an injunction to abstain entirely from this article of food.

Fatty matters need not be given where there is organic disease of the Pancreas; as in that case they are not rightly digested.† This is a rare case. They are sometimes repugnant to the stomach, from other causes.

*I believe however that milk may be given with great advantage. (See paper on Diabetes, read before the Med. Soc. of London, Feb. 10, 1855, reported in *Medical Times* and *Lancet*.)

† See p. 94; also *Brit. and For. Med. Chir. Rev.*, Jan. 1854, p. 63.

The application of oily substances to the cure of Phthisis is a matter of considerable importance. Of late years Cod-liver oil has been used with more success than any other medicine, both as a prophylactic, and as a curative agent in this disease. When this remedy is considered separately in Chap. IV., mention will be made of several theories which have been propounded to account for its mode of operation.

It is important that fresh vegetables should enter into the diet of all persons; an abstinence from them is not unfrequently followed by the development of scorbutic diseases.

Certain adjuncts to diet in constant use throughout the civilized world —Tea, Coffee, and Tobacco—have been found by careful observers* to diminish the waste of the animal tissues, and the amount of excretion. This action is probably connected with the sedative power of these agents; but, should it be verified, these matters may then, from one point of view, be regarded as pseudo-aliments. They do not afford a direct supply to the system, but they render the need of that supply less urgent than it would otherwise have been.

Thus an attention to diet is of great importance in the cure and alleviation of disease; by this means we are enabled, within a certain limit, to regulate the composition of the blood, and through it the nutrition of the body.

Thus are Aliments essentially Restorative, forming and supplying the blood, and from it the several tissues, which are destined to work and to endure, until, like all organic creations, their turn is come to die. Then only are they excreted, and in a different form from that in which they entered; at that time developing into tissues of high organization, they now decompose and retrograde into simpler bodies; at first fitted for life, they are now shaping for destruction. The disease which collectively they are intended to cure is Hunger; which is in fact a call from the blood for the renovation of its failing constituents, a demand for fresh supply from the body, which, because always changing, is always requiring nutriment.

* Böcker, Lehmann, etc.

Any deficiency in the food of those *mineral* ingredients which are essential to the sustenance of man, should, when ascertained, be carefully supplied by the physician. Among these mineral matters are included various salts of Potash, Soda, and Lime, the earthy Phosphates, and compounds containing Sulphur. When any such material has to be supplied, not on account of a disease, but to atone for a deficiency in the food, it comes under this head of Aliments. Vegetable food is more deficient in these mineral substances than animal diet. It does not generally afford the necessary proportion of common Salt, a material of great importance to animals, and entering into the composition of their flesh, blood, and fluid secretions. It is thus that herbivorous animals are driven by their instincts to seek for this mineral in all manner of ways. Horses and cows are improved in health by adding it in small quantities to their provender. The buffaloes grazing on the prairies in America resort in the pursuit of salt to certain spots of soil discovered by them, which are known among the hunters as "buffalo-licks." Even with men, who ordinarily adopt a mixed diet, it seems that the habit of adding salt to their food is universal. It is so mixed up with bread and with all cooked articles that it is difficult for us to discover what would be the result of complete abstinence from salt. But it is commonly affirmed that aggravated forms of dyspepsia, intestinal worms, and even fatal marasmus, have followed such abstinence. There is a tradition that the chief feature of an old and terrible form of punishment of state prisoners in Holland was this denial of salt.

Lime is another important mineral which exists in too small amount in some descriptions of vegetable diet. Birds, who require the carbonate to form their egg-shells, are accustomed to obtain it by pecking at the soil. Lime is deficient in quantity in the grains of some of the Cerealia, especially in that grain of universal consumption—Wheat. To some rustics, who live chiefly upon bread, the wanting proportion of lime may be made up by the use of spring water; to others, by the addition of Milk to the diet; to others again, by the consumption of Potatoes. The fact that the two latter are articles of diet almost universally adopted, even by the poorest, in our country, may perhaps explain the fact that the deficiency of Lime in wheaten bread is not generally felt here. But the contrary may be the case in some parts of Europe, as the rural districts of Germany, where the peasants subsist mainly or entirely upon stale black bread. Thus Liebig proposes, in making dough for baking, to knead the flour with Lime-water. He states that the bread prepared in this way is both wholesome and agreeable. "It may be regarded," he observes, "as a physiological fact, that corn-flour is not a perfectly alimentary substance; administered alone, in the state of bread, it does not suffice for sustaining life; from all that we know, this insufficiency is owing to the want of the Lime so necessary for the formation of the osseous system. The phosphoric acid likewise required is sufficiently represented in the corn, but lime is less abundant in it than in leguminous plants. This circumstance gives, perhaps, the key to many of the diseases which are observed among prisoners, as well as among children brought up in the country, where the diet consists essentially of bread. In this respect the Lime-water bread deserves, perhaps, to attract the notice of chemists."

It is supposed by some that the deficiency of salts of Potash in the food is the cause of Scurvy. (See *Antiscorbutics.*) Others attribute Scrofula and Goître to the want of compounds of Iodine. I do not think that either of these suppositions rests upon sufficient evidence.

Phosphorus, in the form of Phosphates, is abundant in most articles of diet. But in some nervous diseases, where there is an excessive excretion and loss of Phosphates, or in Rachitis, where there is a deficiency of Phosphate of Lime in the bones, it may be advisable to put the patient on an extra allowance of milk, or to mix with the food a minute proportion of an alkaline Phosphate. Phosphate of Lime may be given in powder along with Carbonate of Lime; when the Carbonic Acid liberated from the latter by the acid of the stomach will partially dissolve the Phosphate. (Küchenmeister.) But there is at present little evidence to encourage us in the use of such agents, and we must certainly not suppose that in their administration we are striking at the root of such diseases as these.

If we ever find reason to suspect that there is a deficiency of Sulphur in the food, we may supply it by adding eggs to the diet; or we may advise an increased consumption of such articles as are known to abound in Sulphur, as Mustard, Garlic, and Onions.

Ord. II. Acids.

(*Mineral:*—Sulphuric, Hydrochloric, Nitric, and Phosphoric Acids. *Vegetable:*—Acetic, Citric, Tartaric, Oxalic, and Malic Acids. *Animal:*—Lactic Acid.)

To this list may be added the super-salts of the alkalies, which have an acid reaction.

Although the mineral differ from the vegetable acids in their ultimate action, and are altogether more powerful than them, yet in their proximate effects they are similar. They are all soluble in water, and, when given as medicines, should be so diluted that they can exert no corrosive action on the mucous coat of the stomach and intestines.

Dr. Pereira lays it down as an axiom, that though they all act as acids in the alimentary canal, yet they enter the blood as salts. He considers that they combine with free alkaline matters in the saliva, bile, and Pancreatic juice. (*Materia Medica*, vol. i. p. 171.)

But this explanation seems to me to be calculated to communicate an erroneous idea of their action. For supposing first that they did thus combine with alkalies before entering the blood, yet as more alkaline matter would then have to be secreted to supply that which they had neutralized, they would thus immediately increase the amount of acid in that fluid. The action of acids in the blood is very different from that of their salts. Sulphuric acid does not act like the sulphates of Soda and Magnesia, nor is the action of Hydrochloric acid the same as that of common salt. Again we must remember that the secretions mentioned are either neutral or barely alkaline in their reaction, and that the acid medicine, on passing into the stomach, would meet there with an active absorbent surface, secreting an acid, and not an alkaline fluid. So that it seems probable that the acid would enter the blood as such.

Now the presence of the acid is not unnatural to the blood. The mineral acids exist there in combination, and the vegetable acids have an analogue in Lactic acid.

The blood is alkaline; which is mainly due (in health) to the presence of carbonate of Soda, or (according to Liebig) of an alkaline phosphate of that base. It contains also a small proportion of free Ammonia (or its carbonate,) as demonstrated lately by Dr. B. W. Richardson.* So that the acid, on

* The amount of Carbonate of Soda, according to Lehmann, is 1·628 in 1000 parts. Becquerel and Rodier estimate the whole amount of soluble salts of Soda, excluding the Chloride of Sodium, at 2·5 in 1000. (*Pathological Chemistry*, translated by Dr. Speer, p. 63.) To the escape of free Ammonia from the surface of blood when drawn from the body, Dr. Richardson ascribes the phenomenon of the spontaneous coagulation of its fibrine, previously held in solution by this alkali. This thesis he has supported by a strong array of evidence. (*Astley Cooper, Prize Essay on the Cause of the Coagulation of the Blood*, 1858.)

entering into the blood, passes at once into combination with this alkali, and the result of this is a general diminution of the amount of basic matter in the system, and an increase in that of acid. Thus a free acid may act as a Restorative in cases where there is an excess of alkali in the blood. It may either remain in the blood after entering into combination, or it may pass off by the urine, supplying there the place of a natural acid, which it leaves behind it in the system. It is on such a theory as this that the action of mineral acids in typhoid and putrid fevers has been explained. Huxham long ago recommended acids to counteract the "putrid crasis" in fevers.* They are certainly sometimes of marked service in these disorders. Among later observers of this fact I may number Mr. Day, of Stafford, who has found Nitric acid of great use in malignant Scarlatina. In the Yellow Fever of Tropical climates, an excess of alkali in the blood was discovered some years since by Dr. Blair. This alkali seems to be Ammonia.† I do not affirm positively that there is in all of these fevers an excess of alkali in the blood. Although likely, it is not proved. The explanation is plausible.

Acids are used to correct a phosphatic deposit in the urine, caused by an alkalinity of that secretion. The alkaline urine may be secreted so, as has been observed in petechial fever by Dr. Graves and Dr. Golding Bird, and in insanity by Dr. Sutherland, and may also occur in diseases of the nervous centres; or it may be caused by a decomposition taking place in the bladder, as in chronic inflammation, or in the case of retention of urine from any cause. In the former case the acid may act as a corrective to the fluids before secretion; in the latter case, after it. But it is not always easy to cause acidity of the urine by any medicines. Mineral acids may

* *Essay on Fevers, 2nd edition,* 1750, *p.* 117, etc.

† *Report on the first eighteen months of the Fourth Yellow Fever Epidemic of British Guiana.*—Appendix to *Brit. and For. Med. Chir. Review*, Jan. 1856.

be excreted in other ways, and vegetable acids are liable to decomposition in the system. (*Vide* page 150.)

The use of mineral acids in assisting a weak digestion admits of a simple explanation. For whatever notion we adopt as to the composition of the gastric juice, it is certain that it contains an acid in excess. Now an acid medicine would set free in the blood more of this acid which it is the business of the stomach to furnish, and thus prove useful in that kind of dyspepsia which depends on a failure of the gastric secretion. Hydrochloric acid has been particularly recommended by those who consider it to be the acid normally secreted by the stomach. But Lactic acid, which I believe to be the true stomach acid, is still more likely to be of service. It has been tried by Dr. H. Jones, and has proved very beneficial in his hands. (*Monthly Journ. of Med.*, Nov. 1854.)

Braconnot has found that in some cases of diarrhœa the dejections have a strong alkaline reaction, due to the presence of Carbonate of Soda. In such cases acids may be of use; though this is contrary to the generally received opinion, that sour drinks and fruits are hurtful in all cases of intestinal derangement. All acids, by subverting a tendency to an alkaline crasis, tend so far to counteract fluxes. The vegetable acids have been even recommended as prophylactic against cholera. (See *Antiscorbutics.*)

When not wanted in the system, it seems probable that acids pass in all cases out of the blood in much the same condition as they entered it. Thus, vegetable acids act as diuretics; and mineral, as astringents to the glands generally. The latter, when given in excess, may prove hurtful by causing a lithic deposit in the urine. The addition of a mineral acid to healthy urine causes after some time a deposit of uric acid.

The action of acids on the urine is neither so constant nor so certain as that of alkalies. In attempting to correct abnormal conditions of that secretion, it must be remembered that its reaction is liable to great variations in health. The whole amount passed during a day should be examined together. Dr. Bence Jones states that the urine is most alkaline just after meals, and most acid when a sufficient time has elapsed for the completion of the digestive process. (*Animal Chemistry*, p. 51.)

I shall have afterwards to consider the action of the mineral acids as Astringents; and I must now add a few words on that use of the vegetable acids which has gained for them the title of Refrigerants.

In many febrile cases it is found that diluent drinks containing the free vegetable acids act beneficially in lowering the pulse, and in moderating the progress of the disorder.* These should be distinguished from saline drinks, whether of mineral or of vegetable acid salts; for salts, from their known effects on the blood, would seem to belong simply to my division of Catalytics. But the effect of these vegetable acids seems to be to restore the blood to a more natural condition, and this independently of the action of the diluent with which they are administered. It would seem that in such cases the free vegetable acid acts as a Restorative. In fevers of a low type, where there is a tendency to alkalinity, the vegetable acid may act directly by neutralizing alkali in the blood. But in sthenic fevers also it seems possible that this Organic acid may step in as a substitute for Lactic acid, the natural fuel of the system. In fact, I suppose that in fevers the supply of this natural blood fuel is deficient; that the nitrogenous tissues are then consumed to maintain the heat of the body, causing not only wasting, but tending to keep up the fever by the excessive amount of Oxygen demanded for this abnormal combustion; that in such a case the vegetable acid is well adapted to take the place of Lactic acid, the material

* It is right to state that this is doubted by Dr. Maclagan and others. But on the other side are Dr. Pereira, and the majority of therapeutists.

which is ordinarily oxidized in the system to maintain the animal heat. For though in health the ingestion of such an acid is immediately followed by increased acidity of the urine, when used in fevers it does not pass into the urine. It is then disposed of, or burnt, in the blood. The alkaline salt of the same acid is similarly burnt, as it would be in health; but it leaves a residue, an alkaline carbonate (see p. 153,) which exerts upon the system the usual operation of an alkali.

It has long been considered probable, but may now be said to have been proved by the researches of M. Becquerel, that in febrile disorders and inflammations there is excreted in the urine an excess of Urea and of Urate of Ammonia, substances which are formed by the oxidation of the Nitrogenous tissues. This extra-oxidation probably arises from a deficiency of that matter which is the proper food of Oxygen in the system. This, as we have seen, being the step between grape-sugar and Carbonic acid, must either be Lactic acid, or something similar to it. It must be remembered that no food is usually taken in fever; this would at length quite cut off the usual source of this Lactic acid, which is the starch and sugar of the food, and render it necessary that the animal tissues should continue to undergo oxidation, to maintain the animal heat. (Rheumatism and Gout are an exception to this. See below.) If we compare the commonly received formula of Proteine with those of Lactic acid and Tartaric acid, it will at once be seen as was pointed out some time ago by Dr. Murray, that the latter contain more Oxygen, in proportion to their Carbon and Hydrogen, than is found in Proteine, or albumen.

$$
\begin{aligned}
&\text{Proteine} &&= C_{40}\ H_{31}\ N_{5}\ O_{12}. \\
&\text{Lactic acid} &&= C_{6}\ H_{6}\ O_{6}. \\
&\text{Tartaric acid} &&= C_{8}\ H_{4}\ O_{10} + 2\ HO.
\end{aligned}
$$

Thus, while for 40 equivalents of Carbon, Proteine contains only 12 of Oxygen; Lactic acid contains 40, and Tartaric 50, of that element. So it seems that albuminous matters, containing less Oxygen, would require much more Oxygen for their combustion; this would produce more heat, augment the number of respirations, and keep up the fever. And though it has been proved by Wöhler that free vegetable acids pass out in the urine without having undergone oxidation, yet the condition of fever would probably be an exceptional case. Lactic acid, the natural fuel, being deficient, the alkali with which it should combine must be present in some excess; so it seems likely that a free vegetable acid would combine at once with this alkali as the Lactic acid would have done, and thus be burnt or oxidized instead of the latter. Accordingly, it has been observed by Dr. Rees and others, that the use of these acids in fevers and inflammations is not followed by increased acidity of the urine. (*v. Antiarthritics.*) The action of such an acid is then simply Restorative. Requiring less Oxygen than the Proteine would need to transform it into Carbonic acid, it would thus diminish the number of the respirations, the frequency of the pulse, the temperature of the body,—and in this way allay the fever. It would be strongly confirmatory of this idea if it were proved that the amount of Urea and Urates in the urine is actually diminished by the use of acid drinks and fruits in febrile cases. This hypothesis can only be admitted on the supposition that fever (in which there is likely to be in the blood an excess of uncombined alkali) constitutes an exception to the general rule that the vegetable acids pass through the blood without undergoing change.

Now the salts of these acids with alkalies, which are often administered in the form of effervescing draughts, might exert the same refrigerant action. But there would be this difference; the alkali of the blood would not be required, the acid being already combined with an alkali. M. Wöhler has found that these vegetable-acid salts always undergo oxidation in the system, being converted into carbonates or bicarbonates, and thus reacting on the secretions as alkalies. And so in the same way it seems that the natural lactate of soda is formed into a carbonate, the carbonic acid being afterwards freed from the base, to be excreted by the lungs. By this natural process the quantity of alkali in the blood would not be increased, nor would it be augmented by the action of a free vegetable acid. But the change undergone by a salt of this acid would continually add to the alkaline matter already in the system. And as alkalies have a Catalytic action on the blood, which may prove useful in some sthenic fevers, it follows that these salts have a double action, and are not simply Restorative. (*v. Alkalies; Antiphlogistics; Antiscorbutics.*)

Rheumatism and Gout differ considerably from other fevers, both in their nature, and in the remedies which they require. They are produced by special morbid poisons or agencies, which we are enabled to counteract by certain Catalytic medicines. There is in both of them an excess of free acid formed in the system. Here alkalies are the remedies mainly indicated, for they neutralize the acid. (*v. Antiarthritics.*) Some obscurity rests upon the subject of the use of Citric acid in Scurvy; but as it seems to partake rather of the nature of a Catalytic than of a Restorative action, I have placed Antiscorbutics in the second division. It appears likely that the Catalytic action of the vegetable acids consists in a certain ill-understood control over the progress of various cachexies and blood-degenerations. Among others, it has been asserted, apparently upon a reasonable amount of evidence, that they afford a sort of exemption from liability to Asiatic Cholera. (*v. Antiscorbutics.*)

Though there are individual exceptions (as of Vegetable Acids in Scurvy,) yet in most cases Acids act as simple Restoratives; but Alkalies certainly operate as Catalytics in some disorders, and have thus to be included in both divisions of Hæmatic medicines.

Ord. III. Alkalies.

(Potash, Soda, Ammonia, Lime, Magnesia;—their Carbonates, and neutral Acetates, Citrates, and Tartrates.)

We have to consider the alkalies now as Restoratives,—treating of those cases only in which they are used to restore a wanting material to the blood or fluids of the body.

That they pass into the blood, is proved by their solubility, and their appearance in the secretions; and that they are natural to it we know, because they are all found in it.

Wöhler has demonstrated the curious fact, that the neutral salts of the alkalies with vegetable acids undergo oxidation in the blood, being transformed into carbonates. Those among these salts which act as Purgatives are found, when given in large doses, to pass out unchanged along with the contents of the intestines. (Laveran and Millon.) But in small doses they are apt to be oxidized in the system, and then pass out in the urine. Thus it may be easily shown how the neutral (bibasic) Tartrate of Potash may, with the addition of ten atoms of oxygen, produce two equivalents of bicarbonate of potash, together with four of carbonic acid and four of water.

$$\begin{aligned} 2\ KO,C_8H_4O_{10}+10\ O &= 2\ KO+8\ CO_2+4\ HO. \\ &= 2\ \overline{(KO,2\ CO_2)} + (4\ CO_2+4\ HO.) \end{aligned}$$

Again, one equivalent of the neutral acetate of potash, with eight of oxygen, will make one equivalent of the bicarbonate, two of free carbonic acid, and three of water.

$$KO, C_4 H_3 O_3 + 8\ O = KO + 4\ CO_2 + 3\ HO.$$
$$= KO, 2\ CO_2 + (2\ CO_2 + 3\ HO.)$$

This carbonate, easily decomposed by any acid, is equivalent to a free alkali. Thus small doses of these salts may fulfil a double function. They may supply the respiratory process, as has already been explained. They may also act on the secretions as alkalies. Bence Jones has found two drachms of Tartrate of Potash, dissolved in four ounces of water, render the urine alkaline in thirty-five minutes. Lehmann has discovered that in persons living on a mixed diet, ten grains of Acetate of Soda will produce this effect in two or three hours, but in those subsisting on vegetables alone, two drachms or more may be taken before the alkalinity results.

Mialhe has observed that violent exercise renders this oxidation rapid, and repose retards it. (*Chimie appliquée*, p. 79.)

Such a combustion of an Acetate or a Tartrate, consuming Oxygen and producing Carbonic acid, is in all probability strictly analogous to a natural burning of Lactate of Soda always going on in the blood for the maintenance of the animal heat.

Wöhler finds that those vegetable-acid salts in which the acid is in excess are not thus decomposed, but tend to render the urine acid instead of alkaline.

My own experiments, recently undertaken, on this subject, would lead me to believe that some variation is to be expected in these results. I am disposed to differ from Wöhler so far as this,—that I would not make the rule absolute in either case. That is, as to alkalinity of urine being produced by the neutral salts, but never by the acid salts with the vegetable acids. There seem to me to be several causes which may disturb the constancy of such results. First, a fluent state of the intestinal canal, which may cause even a small dose of a neutral salt to pass off by that surface without affecting the urine. Secondly, an excess of alkali in the system, as (probably) in fevers, may, by combining with it, convert an acid salt, or even a free vegetable acid, into a neutral salt, and so determine its combustion. Thirdly, the reverse may happen. An excess of acid in the stomach, in the blood, or in the food, may convert a neutral salt into an acid salt, and so prevent it from rendering the urine alkaline. On this account it is difficult to produce such an alkaline reaction in some dyspeptic and gouty patients.

On this ground also I am disposed to account for a certain discrepancy between the results of some French experimenters (as Laveran and Millon) and the Germans (as Lehmann and Wöhler.) With those who are always drinking sour wines there must be great difficulty in rendering the urine alkaline, while this result would be rather favoured than otherwise by the amount of heavy sweet beer which Teutonic philosophers are accustomed to imbibe.

Thus, as they pass unchanged into the fæces, and under certain rare circumstances may possibly pass unchanged into the urine, these neutral salts of the alkalies with vegetable acids, though unstable in their nature, are not always decomposed. But though by no means themselves equivalent to a free alkali, yet as their natural tendency is to form by oxidation in the blood a Carbonate which is equivalent to a free alkali, I have termed them alkali-producing, or *Kaliogenic salts*.

To exert the operations of an alkali on the system, the fixed alkalies may be more relied upon than Ammonia. The latter produces an admirable effect while it remains, but on account of its volatility it is apt to be rapidly excreted from the body by the exhalant surfaces of the skin and lungs. The fixed alkalies are more slowly excreted in the urine, when not wanted in the system. The natural alkalinity of the blood is due to the presence of free Soda and Ammonia (see p. 157.) Potash, when given as a medicine, must liberate these weaker alkalies from their saline combinations. Thus Potash rarely, if ever, exists free (or carbonated) in the blood. It acts by setting free Soda or Ammonia. Soda itself, being stronger as a base than Ammonia, could not exist free were there any surplus of ammoniacal salts present.

Chalk and Magnesia, being insoluble, can only act as alkalies in the intestinal canal. For, unless neutralized and dissolved by an acid there, they cannot be absorbed. But, by counteracting an acid in the stomach, they produce in the end the action of an alkali on the whole system, though indirectly. They bring about ultimately the same effect, though weaker, as that of the true alkalies.

The vapour of burning Tobacco contains Carbonate of Ammonia in considerable quantity. This must necessarily be absorbed to a large extent by the mucous surfaces of the mouth and lungs of smokers. Regarded in this point of view, the practice of smoking, when continued, may be looked upon in the same light as a course of alkaline medication. It may be attended with the same risk or advantage. It must be ill suited to those in whom there is a tendency to alkalinity of the humours, and better adapted to the case of those gouty or dyspeptic subjects with whom the contrary obtains. But of course the therapeutic action of the Nicotia and other volatile principles of Tobacco must be separately taken into account.

Alkalies are used wherever there is an excess of acid in the system, whatever that acid may be. Alkali should naturally be present to neutralize it, for it is unnatural to have a large excess of acid in the secretions, or any excess in the blood. We thus administer alkalies on the restorative principle. They are not always excreted; but whether excreted or not, they tend to render the secretions neutral and alkaline by increasing the quantity of basic matter in the system. Alkalies being more stable than acids, and being more invariably secreted by the kidneys, it is more easy to render the urine alkaline than to make it acid.* Alkalies are thus of use in a tendency to lithic acid deposit. The bicarbonates are probably the best for this purpose, for they may be given in large doses, being less irritating. The celebrated Vichy water contains bicarbonate of soda. Lime-water has been used as a solvent for stone. These all act by first diminishing the acid of the blood, and subsequently influencing the secretion of the urine, which secretion, acting as a counterpoise to the

* Mialhe considers that there is more danger in giving acids than in administering alkalies, for the natural secretions of the system being generally alkaline it is not so easy to disturb their condition by the use of alkalies as it is by that of acids. But it must be remembered that the most important of the secretions, the urine, has an acid reaction; that it is not very easy to increase this reaction; and that even this may be done to a considerable extent, as shown by Dr. B. Jones, without precipitating Uric acid, or causing dangerous consequences.

condition of the blood, may be generally taken as an index to it. The alkalinity of urine thus produced is generally caused by Ammonia, which is set free from its combinations by the fixed alkali. Dr. Parkes finds that Potash generally passes out in combination with Sulphuric acid, causing more of this acid to pass into the urine than is so excreted in health. (*Brit. and For. Med. Rev.*, Jan. 1853, 1854.) Dr. B. Jones states as the result of his experiments, that the exhibition of Ammonia may neutralize acidity of the stomach, but is not followed often by alkalinity of the urine. (*Philosophical Transactions*, 1851.) Alkalies which react upon the urine in such a manner as to prevent a deposit of lithic acid, come under the denomination of *Solvents*, and will again be considered as members of that order.

Dr. Pereira recommends alkalies in cases of dyspepsia and pyrosis, when there is an excess of acid secreted by the stomach. Yet this must not always be taken as an indication for their employment; though it is a tolerably safe rule, when this is known to proceed from a gouty cause, or is accompanied by a marked lithic diathesis, and excess of acid in the urine, to administer alkaline medicines. But it is known that there are some cases of excessive stomach acidity, as those caused by the presence of *Sarcina ventriculi*, in which the urine at the same time is actually alkaline. The acid in the system is so monopolized, as it were, by the stomach, that there is none left to maintain the reaction of the urine. In such cases, instead of an alkali being given, it is doubtful whether an acid may not be of more service.

Ammonia will be again enumerated as a stimulant—Potash as a catalytic—and lastly, all the alkalies as diuretics.

The alkalies are useful in gout and rheumatism in diminishing the acidity both of the blood and of the secretions. It is often advantageous to apply an alkaline wash locally around an affected joint, in the fluids about which the morbid process seems especially to have fixed itself. If we may receive a certain theoretical explanation of these two kindred diseases, still more light will be thrown on the advantages attending the employment of alkaline restoratives. To this I shall recur when I consider the Catalytics which are used to counteract these same disorders,—not, as here, by restoring a wanting material, but apparently by determining the process in a different direction, and thus checking it as a disease.

When fatty substances are digested and assimilated with difficulty, on account probably of a deficiency of alkaline matter in the bile, an alkaline medicine may aid in causing their healthy absorption. Alkalies dissolve fats. Given in excess, they keep them so fluid as to prevent their deposition in the tissues and cause their excretion from the body. In those rare cases of undissolved fat in the fluids, as evidenced by 'lactescent serum,' or 'chylous urine,' an alkaline medicine may be appropriate. In the far more frequent tendency to 'fatty degeneration,' or interstitial deposit of fat in the vessels and organs, we may sometimes hope to do good by the same means. We may succeed when the fault is in the fluids; we can do little service in a strictly organic disease.

An alkaline course is recommended by Dr. Budd for biliary calculi. The alkali cannot dissolve the Cholesterine, or peculiar waxy matter of these concretions, if we may trust to Fauconneau-Dufresne; but it may perhaps dissolve or remove those fatty materials out of which the Cholesterine is formed.

Alkalies likewise dissolve organic compounds of the albuminous group, and prevent the coagulation of fibrine. In excess, they retard nutrition, and cause spareness of system. In surgical cases, and in aneurisms, where we wish to promote repair or injuries, or to cause a deposit of fibrine, they are used on the catalytic principle. (See *Antiphlogistics.*) They are indicated as Restoratives in those cases of fibrinous coagula in the great vessels during life, of which a deficiency of alkali in the blood would seem to be at least an efficient cause.

Mialhe administers alkalies in Diabetes mellitus. He considers that in that disease the natural transformation of glucose into lactic acid is hindered by a tendency to acidity in the blood. For he maintains that the presence of an alkali is necessary to this transformation. (*Chimie appliquée*, p. 75, etc.) The practice has succeeded in his hands, but not in those of others. The balance of theoretical reasoning seems likewise opposed to it. It is denied by other chemists that there is any deficiency of alkali in this disease, and it is found that the transformation of glucose will occasionally take place in the stomach itself, in an acid gastric juice.

In Rickets of children, many pathologists* have assumed that there is an excess of acid (lactic, oxalic, or phosphoric) in the system, and that this holds phosphate of lime in solution, carries it off in the urine, and thus prevents its appropriation by the bones. Were this theory proved—which it is not—it would certainly be a very strong argument in favour of an alkaline regimen in this disorder.

It would appear that some skin diseases (especially *Vesiculæ* and *Pustulæ*) are connected with or accompanied by an acid and irritating state of the perspiration,† an indication perhaps of a similar condition of the blood. This may be met by the exhibition of alkalies internally, or by their application externally in the form of lotions. Cases of Eczema, Acne, Impetigo, etc., are often benefited by such treatment. To enable the alkali, when given internally, to affect in a direct manner the seat of disease, it should be caused to pass off by the skin as a diaphoretic, which may be done by keeping the patient very warm, and confining him to the recumbent posture. (*v. Diaphoretics.*)

It may be a matter of doubt to some whether or not I have done right in excluding SALINES from a place among the Restorative orders. For myself, I do not think that I am justified in giving them such a place, judging at least from the present state of knowledge. I do

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* Merei, Marchand, Ure, Schmidt, Weatherhead.

† Hippuric acid has been discovered in the sweat in Icthyosis.

not think it is proved that any disease depends on the want of any particular salt in the blood, or can be cured by the supply of such salt. Here I should perhaps except Chloride of Sodium, mentioned among Aliments, because this is an essential ingredient of our daily food, and its withdrawal will cause disease, just as the withdrawal of any other alimentary principle.

Now with regard to the alkaline salts in the serum of blood we know this much—that variations in their amount do occur in several diseases, though for these variations no obvious reason can be given. According to Lehmann the serum of man's blood in health contains 8·8 per cent. of salts, and its ash has the following composition:—

Chloride of Sodium	61·087
Carbonate of Soda	28·880
Chloride of Potassium . . .	4·054
Phosphate of Soda	3·195
Sulphate of Potash	2·784
	100·000

Arterial contains more salts than venous blood. The following variations in disease are deduced from the observations of Schmidt, Zimmerman, Poggiale, Simon, Becquerel, Rodier, etc. The amount of these blood salts is much diminished in acute inflammations; increased in the low Exanthemata; much increased in Dropsies. In malignant cholera the salts are much diminished, according to Simon; while Becquerel states that their proportion (especially of Chloride of Sodium) is much increased in this disease. Leonard and Salvagnoli find that they are often doubled in Dysentery, in Scurvy, and in malignant forms of Intermittent fever.

One thing may be said of all these variations, that they are probably in every instance to be ranked among the consequences, and in no case among the causes, of the disease. Could we satisfactorily supply these salts when wanting, the condition would be likely to recur immediately, so long as the cause lasted.

I know of no instance in which we can cure inflammation by supplying salines to the system. Salines operate as mild antiphlogistics in inflammatory disorders; but so long as the inflammation continues, they are powerless to alter the proportion of salts in the blood.

Just as we explain the increase of salts in Dropsy by the arrest of the free renal secretion, so their supposed diminution in Cholera blood has been referred to the immense evacuation of saline serum from the intestine. Some have thought that they could cure Cholera by supplying these salts. But, as we might have expected, Dr. Stevens' saline treatment does not seem to have been at all more successful than the many other plans proposed for the cure of this intractable epidemic. Some have injected the saline solution directly into the veins. Formulæ for such solutions have been written by Dr. Latta, Dr. O. Rees, Dr. Marcet, and others. But the results have been most melancholy. When we read the statement of Dr. Griffin (*Med. Gaz.* vol. xxii. 319,) that out of 282 recorded cases 221 died, and reflect upon the probability of other unsuccessful trials having never been published at all, we can hardly escape the conviction that a much larger proportion of these patients would have recovered if they had been left alone. Besides his recommendation of salines in Cholera, Dr. Stevens warmly insists upon their use in malignant fevers, in which he supposes that they restore deficient saline matter to the blood. But as in such cases salines are certainly in excess in the blood, this theory is founded on a misapprehension of the fact. (*Observations, etc., on the Blood*, 1832, p. 356.) In discussing Antiscorbutics I shall have to refer to the theory of Dr. Garrod, that Scurvy is due to a deficiency in the food of the salts of Potash, and is therefore to be treated by the use of these salts. I shall merely state here that it seems that the blood in Scurvy contains an excess of these salts, rather than a diminished amount; that I dispute the statement as to the deficiency of Potash in the food of scorbutics; and that all the evidence which I have collected on the subject is opposed to the idea that Scurvy can be treated successfully by the administration of these salts.

I have thus enumerated the chief reasons which induce me to deny the right to *Salts* (excepting those included among Aliments and Solvents) to a place among the Restorative orders.

Alkaline salts belong to the Catalytic order of Antiphlogistics; they are also included in several of the orders of Eliminative medicines. The salts of the alkaline earths are very analogous to them. To Sulphate of Magnesia, as the representative of saline purgatives, a separate article will be devoted in Chap. IV. The salts of the other metals are extremely various in their operations on the system. Iron, the only one of the metals proper which is natural to the blood, occupies therefore a place among Restoratives. (*Chalybeates.*) The other metals are distributed among the first two and last three orders of Catalytic Hæmatics.

The action of Catalytics is more obscure than that of Restoratives, but there is generally a broad line between them. The most difficult case is that of the medicines used in ague and other periodic diseases; of these, for certain reasons that I shall state, I have grouped Quina and Tonics among Restoratives, placing Arsenic among Catalytic medicines.

It seems to me that Cinchona bears the same relation to Arsenic in the treatment of ague, as Alkalies to Colchicum in gout; the former, in each case, supplying a needful material, the latter neutralizing a morbid process.

Thus, when air has been rendered impure by breathing we may render it again respirable by adding fresh oxygen; but still more certainly, by neutralizing the carbonic acid.

Ord. IV. Tonics.

Under this term I intend to include only the bitter principles of vegetables. The chief medicines of this order are as follows:—

(*Alkaloids and neutral principles.*—Quina, Cinchonia, Quinidia, Bebeerine, Narcotine, Salicine, Caffeine, Piperine,* etc.

Bitter drugs.—Cinchona, Quassia, Cusparia, Gentian, Calumba, Chiretta, Centaurium, Menyanthes, Rhubarb, Hops, Elm and Willow barks, Tansy, Wormwood, Chamomile, Cascarilla.)

The power by virtue of which these medicines are enabled to act as Tonics, is due, in each case, to a vegetable alkaloid or neutral principle, having a bitter taste. All of those mentioned above, with the exception of Salicine, contain Nitrogen. The uses of Tonics are of a twofold nature. Firstly, they are of use in simple debility and in atonic dyspepsia. Here they give an appetite, increase the muscular strength and powers of digestion, and improve the general health. In the second place, they have all, more or less, a curative power in ague and other periodic disorders, caused by Marsh miasm. Many explanations have been given of this curious and double action of vegetable bitters; and some erroneous theories have been assumed, and false analogies attempted, in the classification of these remedies. The subject is certainly a difficult

* This has been used in intermittents with some success. The ancients, to whom Bark was unknown, used to employ Pepper in Agues. (*Celsus, lib.* 3, *cap.* 12 *et seq.*)

one, and there are, at starting, several questions which require a distinct consideration and reply. Upon the answers given to them it must depend whether they should rightly be grouped with blood-medicines or with nerve-medicines; and, if the former, with Restoratives or with Catalytics.

Do these medicines act primarily in the blood, or on the nerves? Is their action of a permanent character? Are there any substances in the blood which resemble them? May they remain in the blood, or are they always excreted? If acting in the blood, are they wont to effect a cure by supplying to it a material wanting, or by counteracting in it a morbid process?

These questions require each a satisfactory reply, before it can be proved that I have done rightly in classing Tonics among Restorative medicines; for they coincide with the minor propositions in which I have defined the action of such remedial agents.

Quina may be taken as the type of the whole order. It is the most powerful; and the others all more or less resemble it. Perhaps Cusparia bark comes nearest to the Cinchona alkaloids in its anti-periodic action. It is worthy of remark, that some common bitters, which owe their efficacy, not to alkaloids, but to neutral principles, as Quassia, Calumba, and Gentian, possess the least control over periodic affections.

There can be no doubt that these active principles are all absorbed, and pass into the blood. They may easily be dissolved out of the vegetable which contains them, if not by simple water, at all events by such an acid liquid as we find in the stomach. We possess positive proof of absorption in the case of Quina, which has been detected by Tiedemann and Gmelin in the blood of a patient to whom it was administered.

Having them now in the blood, we arrive at the first question. *Do Quina and other vegetable Tonics act on the blood,* *or on the nerves?** This has been answered at once by many writers, as if it were a thing of great simplicity. But it does not seem to be so. Tonics, as we know, have the power of communicating health and strength in debility produced by various causes, and also of arresting the progress of intermittent fever. Do they effect these things by bettering the condition of the blood, and, from it, that of the system at large, or do they at once, and in the first place, influence the nervous system? This is an important question, and it has been variously answered.

Dr. Pereira, in his classification of medicines, ranks them among *Cinetics* (κινέω, to move,) which are defined to be medicines exerting a power over the motor system of nerves, and through them on the muscles. But in a subsequent account of Quina, he states that its action is quite inexplicable, and that its use in Ague must be ranked with some other special and ill-understood actions, as that of Mercury in Syphilis, or of Arsenic in Lepra.

Dr. Neligan (in his work *On Medicines*) lays it down that Tonics act as stimulants when given to a healthy man. Dr. Pereira, on the contrary, states what is more consonant with general experience, *i. e.* that a moderate dose of a tonic has little or no effect on a man in perfect health. Dr. Neligan admits that their action is permanent, and produced slowly; he also declines any explanation of the action of Quina and others in Ague, calling them specifics.

Some other authors have been still more decided in classing Tonics with nerve-medicines. Dr. Guy (in his edition of *Dr. Hooper's Physician's Vade Mecum*) considers that Stimulants and Tonics should rightly be classed together, for that Stimulants act as Tonics to the weak, and Tonics as Stimulants to the strong. Dr. Dundas, too, considers the action of Quina to be on the nervous power.

It should be observed, that the irritant action on the stomach of a large dose of a bitter medicine appears to have been the chief foundation of this frequent opinion of the stimulant action of Tonics. The irritable stomachs of nervous persons are more easily affected in this way. Some too are met with who bear Tonics worse than others, on account of an idiosyncrasy or peculiarity of constitution. But this irri-

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* Some may say—neither the one nor the other,—but by an action on the muscles or the glands. For the first, Quina is not in any sense astringent. For the second, it is not eliminative, as will be shown presently. The alternative is between the blood and the nerves.

tation, and the headache and febrile symptoms which succeed to it, do not surely constitute the proper action of a tonic medicine, which is found to operate most favourably when given in too small a dose to produce anything like a stimulant effect. Nor do I think it proved that any true stimulants are capable of communicating a permanent tone to the system, or to any part of it. (*v. Stimulants.*)

Dr. Ballard also (in *Ballard and Garrod's Materia Medica*) states that Tonics act first upon the nerves, and through them on the muscular system. He opposes them to sedatives, and ranks them with Stimulants; quoting Strychnia as an example of a stimulant which gives tone to the muscular system. But, in the first place, this alkaloid is quite exceptional among stimulants; and further, the comparison with Tonics seems unnatural, inasmuch as the action of Strychnia is more or less immediate, not slow and permanent, and it evidently influences the spinal system of nerves in the first place.

The results of large doses of Quina, in producing determination of blood to the head, ringing in the ears, and vomiting, seem to me to mark its action as an irritant poison, and not to be characteristic of Tonic medicines. (*v.* p. 106.) For all medicines, except only the most powerful sedatives, act as irritants on the stomach and intestines when given in an overdose. So that an action, thus common to all, cannot be considered as characterizing any.

In high fever, the function of absorption being suspended, the bitter remains in the stomach, and irritates it in such a manner as may prove dangerous. Here, most of all, it stimulates the stomach and excites the pulse, and for that very reason can seldom be used without risk. For when Quina stimulates, it is inapplicable; when it cures, it does not stimulate.

The action of Tonics has been more correctly defined by another able authority. "Tonics," says Dr. A. Billing, "are substances which neither immediately nor sensibly call forth actions, like stimulants, nor repress them like sedatives, but give power to the nervous system to generate or secrete the nervous influence by which the whole frame is strengthened." This definition I would accept in a modified sense, considering that no permanent alteration in the nervous system can be produced without a primary impression on the blood.

On the whole, it seems to me that those authors who, in defining the action of Tonics, have commenced by saying that they act on the nervous system, have started with a mistaken notion; and I am more of the opinion of Dr. A. T. Thomson, who classes them as medicines which act on the muscular and sanguiferous systems.

I consider, then, that Quina is not in the first instance a Neurotic medicine; and for the following reasons. The action of other nerve-medicines is distinguished by the following signs. It is quick, and very rapidly follows the administration of a substance. It is transient, and does not endure. It requires no particular state, but takes place in health: thus Alcohol stimulates and intoxicates both healthy and sickly, and Digitalis would subdue a Hercules. Most Neurotics are capable of acting without entry into the blood at large; mere contact with the nerves, as when they are applied externally, being sufficient for their action on those nerves. Again, Neurotics are chiefly used in cases in which the nervous system is unusually excited or depressed, and are of no permanent efficacy in diseases depending on blood-disorder. The action of Hæmatics is of an opposite kind.

Now is the primary action of Tonics distinguished by the above signs? They are not quick and sudden in action. Their effect is not transitory. It is not evidenced in health as well as in disease. They do not act on the superficial nerves, when applied to them. In each case the answer must be a negative. In all of these particulars the operation of vegetable bitters differs from that of Neurotics, and coincides with that of Hæmatic medicines.

It appears that their action on the nervous and muscular systems is secondary. They could hardly in either case effect any permanent improvement without first acting on the blood, if we may argue from known analogies. For Neurotics and Astringents, which operate directly on these two systems, are alike transitory in the results of their action.

Another demonstration is required, before the presumption thus established can approach to a certainty.

We require proof to show that the disorders in which Tonics are used are blood-diseases. This does not seem to be difficult.

The condition of Debility, whatever its proximate cause, seems always to be traceable in the first place to a want in the blood, which interferes with the due exercise of their functions by the nerves and other organs, by impairing their nutrition. It follows fevers, and accompanies chronic diseases, in both of which cases the blood has been exhausted by continual waste and excretion, without the maintenance of a proper supply. In cancerous, scrofulous, scorbutic and dyspeptic habits, the blood may be deteriorated by a fault in the assimilative processes. When in these instances there is marked Anæmia, iron may be of most service; but when the blood is poor without any apparent deficiency of red colouring matter, then are bitter Tonics needed to improve its condition, and form a valuable adjunct to the special remedies that the case may require. They ought not, as a general rule, to be administered in high fever, or when the pulse is hard, the tongue coated, or the stomach irritable. A loss of appetite, a nervous headache, a soft compressible pulse, a quivering tongue, a flabby condition of the muscles, with general inertia and indisposition to exertion, are indications for their employment. In some cases emetics and antimonials, in others mild purgatives, are of use in preparing the system for their reception.

It seems then that Debility is to be attributed generally to the state of the blood, and is to be cured by improving it. By so doing, we may communicate tone to the muscular system, improve the appetite, and increase the nervous force.

Ague, or Intermittent fever, is also a blood-disease. If it were only from the analogy of other fevers, we might infer this. But there are more particular proofs. This disorder is caused by the exposure of the system to a certain peculiar poison or miasm, which is generated in the ground in certain places, and subject to known laws. The result of the influence of this miasm is a process in the blood which has been compared to fermentation, and which produces regularly-recurring paroxysms of a peculiar kind. There is apparently some disturbance in the great calorifacient process, in which the blood is concerned, and not the nerves. Each fit commences with shivering; there is then a hot stage; and finally sweating. The attack then goes off, seemingly as if the poison that caused it were eliminated in the perspiration. But it is not all gone. After working in the blood for a definite period, most commonly two days, it again breaks out, and the same train of symptoms recurs. Thus this strange disorder, both in its origin and in its progress, appears to be seated in the blood. So also are its results evidenced there. Continual Ague deteriorates that fluid, causing general anæmia, and producing more or less enlargement of the spleen, which could only be brought about by some faulty condition of the circulation.

Against these proofs it has been urged that the nervous system has certainly an influence over this disorder, for that a sudden alarm has been known to arrest it. But this may occur also with other blood-diseases, and it does not prove that the nervous system is at all connected with their origin. It can hardly be supposed that Goître or Scrofula, is ever caused by a derangement of the nerves. And yet Baron Alibert relates an authentic case of a French lady who had a large goître, which for a long time resisted all treatment, but which nevertheless disappeared entirely during the brief Reign of Terror in the French Revolution. In addition to these arguments it may be urged that Ague is often, if not always, connected with deranged hepatic functions, a fact that again points out that disease as a blood disorder.

Seeing then that the medicines of this order of Tonics differ in each particular of their action from those remedies which influence the nerves directly, and that the diseases in which they act beneficially are essentially blood diseases, there are sufficient grounds for concluding them to be Hæmatics, or blood-medicines.

We have now to consider the remaining minor propositions, which treat of their action as Restoratives; to ascertain whether they have been rightly allotted to this division.

Are there in healthy blood any substances which resemble them? This will appear to be a question of no small difficulty, when it is considered how little information we have actually obtained respecting the chemical composition of the vital fluid. It is nevertheless desirable that we should inquire into it to the best of our ability.

During the last few years, many propositions, intended to throw a light upon physiological science, have emanated from the fertile pen of M. Liebig of Giessen, who is rightly and universally ranked among the most illustrious of modern chemists. There are two which especially bear upon the present subject. In his first work on Organic Chemistry (p. 182) he argued, that whereas the alkaloids Quina and Morphia resembled the brain substance in their chemical constitution, they were therefore enabled to exert a direct control over that organ by influencing its nutrition. But it is impossible to accept this explanation. The composition of the brain has been since more accurately investigated, and it has been shown to consist mainly of a mixture of albumen and fat. Now there is no reason why these substances should have a special affinity for albumen and fat in the brain, any more than for the same elements in other parts of the body. There is also no analogy at all between Quina and Morphia as medicines beyond their resemblance in chemical constitution. The theory seems to be altogether groundless.

Another and a more important suggestion has been made by the same chemist. He has pointed out a chemical analogy between certain vegetable compounds and a substance which exists in the bile. He has shown that for the most part the elements of the bile re-enter the blood after passing into the intestine, scarcely more than the colouring matter being finally excreted with the fæces. It is found that if an enema of bile be injected into the rectum, it becomes absorbed there, and does not afterwards pass out into the urine.* (*Animal Chemistry*, p. 77.)

Many various and conflicting statements have been made as to the chemical constitution of the bile. But the subject may now be considered to be settled, at least for the present, by the laborious researches of Strecker. He finds that human bile essentially consists of two compound organic acids in combination with Soda, this alkali being also present in the state of Carbonate. The two acids are named *Glycho-cholalic acid* and *Tauro-cholalic acid*. Both of them contain *Cholalic acid*, a ternary compound; but in the first this is united with *Glycocine*,

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* Possibly some parts of the bile, besides the colouring matter, are truly excrementitious. But part of it is needful in the animal economy, as has been proved by experiment. M. Schwann found that when the contents of the bile-duct in dogs were caused to discharge themselves externally through a fistulous opening in the wall of the abdomen, the animals quickly wasted away and died. In some cases of jaundice the constituents of the bile appear to be vicariously excreted by the kidneys; and perhaps the great depression produced by that disorder may be partly accounted for by the impossibility of the re-absorption into the blood of these substances, naturally formed by the liver. Having passed into the urine, there is no provision to enable them to return.

or Gelatine-sugar; and in the other with *Taurine*, a soluble crystalline body, having the composition $C_4 H_7 N S_2 O$.

It should be stated that long before these inquiries of Strecker, Liebig and others had obtained Taurine from bile, but in their analysis they did not discover that it contained Sulphur, but determined for it the formula $C_4 H_7 NO_{10}$. Liebig pointed out a relation between Taurine and the alkaloid Caffeine. (*Organ. Chem.*, 1842, p. 80.) Löwig afterwards confirmed the formula advanced by Liebig, and showed that one equivalent of Binoxalate of Ammonia and four of water contain together the same elements as an atom of Taurine. (*Simon's Anim. Chem.*, vol. i. p. 47, *Syd. Society.*) Such results can hardly be reconciled with those above, but by supposing the Taurine to part easily with its Sulphur under certain circumstances. Dr. B. Jones conceives that the biliary principles undergo some chemical change before being absorbed. At all events, it is likely that the Sulphur in Taurine would be liable to that oxidation into Sulphuric acid which so commonly happens to free Sulphur when introduced into the blood.

M. Liebig has discovered a strong resemblance between this Taurine and the vegetable alkaloids, and I think that, without theorizing at all on the subject, it may safely be affirmed that with the existence in the blood of such materials as this, we cannot say that we have not in that fluid an analogue to such principles as Quina. Ox-gall, or the bile of an ox, when administered as a medicine, has been found to have an action which strongly resembles that of Tonics. It appears that both the bitterness and the tonic properties reside in the Taurine.

Now the chief point in which the tonic alkaloids differ from the recognised quaternary principles in the blood, is that the former are crystallizable, as well as soluble in water. Taurine is soluble in water, and crystallizable; is thus not only therapeutically, but chemically, analogous to the tonic bitter principles; it also contains the same four elements as Quina, with the addition of Sulphur.

Taurine has recently been artificially prepared* by Strecker,

* From the *Isethionate of Ammonia* of Regnault. Strecker confirms the above formula, given by Liebig, for Quina, but doubles the equivalent.—*Comptes Rendus*, Sept. 18, 1854.

—a most important fact to our argument. For if it can be eliminated by the chemist from one crystalline substance, why not by the human system from another? The same ingenious investigator has surmised, with much show of reason, that the atom of Quina is made up of three organic radicals, and has constructed some new compounds by combining other elements with it.

Thus were it necessary, I suppose that the Quina or other tonic principle might without much difficulty be transformed into Taurine by chemical changes in the blood. But I see no particular reason for supposing that such a change takes place. Quina hardly differs more from Taurine than several members of the chain of Tonic alkaloids differ among themselves. This may be seen by placing them side by side.

$$\begin{aligned}\text{Quina} &= C_{20}\,H_{12}\,O_2\,N\\ \text{Salicine} &= C_{26}\,H_{18}\,O_{14}\\ \text{Caffeine*} &= C_8\,H_5\,O_2\,N\end{aligned}$$

and,

$$\text{Taurine} = C_4\,H_7\,O_6\,N + S_2$$

These substances do not all possess basic properties; nor do they all contain the four organic elements; nor are the three elements, common to all, present in similar amounts; in fact the only point of strict resemblance is that they are all tonic and crystallizable. And in these respects Taurine resembles the rest.

It is now sufficient for us, if we have ascertained that there is naturally to the system, and in the blood, a substance which resembles Quina. We may be allowed so far to infer that the presence of the latter substance in that fluid would not be unnatural to it.

Having dismissed the second of the minor propositions which relates to Tonics as Restorative medicines, we pass on

* The bitter principle of coffee possesses undoubted antiperiodic powers, and may be given in the same doses as Quinine.

to the third. *Are Quina and the vegetable bitters necessarily excreted from the blood?* If not, we may conclude it as likely that they may remain in it, and thus be enabled to act as Restoratives.

All that is known on this subject agrees to confirm us in giving a negative answer to this question. Quina is not necessarily excreted from the blood. That is, it appears that when given in small or medicinal doses, it is not excreted at all; but, when given in an excessive or over dose, Quina, like other Restorative medicines, will make its appearance in the urine. Wöhler and Frerichs could not at first discover Quinine in the urine, but they obtained proof of its presence there after administering a large dose. Dr. W. Herapath, of Bristol, made a very careful analysis of the urine of a patient suffering from Tetanus, to whom forty grains of the officinal Disulphate were administered in the twenty-four hours. In half a pint he discovered an amount of Quina equivalent to 1·884 grains of the above salt; and supposing two pints of this secretion to be voided per diem, this indicates 7·536 grains, as excreted from the system, out of forty grains ingested. (*Pharmaceutical Journal*, vol. xiii. p. 216.) Dr. Herapath supposes, as I do, that the remainder of the Quina (in this case, apparently, four-fifths of the whole) was either assimilated in the body or destroyed in its transit through the vascular system. But supposing the alkaloid to be administered to a patient in whose system it is not required, it might then be excreted in larger amount than in the above instance.

The same non-necessity of excretion may be said to apply to all the Tonic principles. There is no proof that they are necessarily excreted, but there is every reason to suppose that they may remain for a while in the blood.

Let us then consider the last question. *Can Quina, or substances like it, improve the condition of the blood when deficient in any of its natural materials?* We know that it is capable of curing simple debility, ague, and remittent fevers. It appears that it has also been successfully used of late by Dr. R. Dundas, in large doses in the treatment of typhoid or continued fever. Supposing it to be proved that this agent operates in the blood, does it remedy a disease by supplying something wanting, or by counteracting something present in that fluid?* In fine, is its operation that of a Restorative or a Catalytic medicine?

The probabilities which have been established, that it is not unnatural to the blood, and is not always excreted from it, are in favour *à priori* of its being Restorative. Catalytics are generally unnatural to the blood, and are excreted because they cannot remain in it. Besides, a Catalytic has generally some peculiar action on the blood in health; but a Restorative, in moderate doses, none,—only evidencing its operation when supplying a previous want. In this also Quina and its congeners agree with Restoratives, and differ from Catalytic medicines.

Arsenic is of use in Ague; and Arsenic is decidedly a Catalytic in all these particulars. In other respects, too, it differs widely from Quina. The latter is employed in debility, which depends evidently on some want in the system, and not on any morbid agent. Arsenic, on the contrary, is of use in Lepra, which, like other skin diseases, must be caused by some morbid agency, though we know not what precisely. But some diseases may be cured in two ways; either by the supply of something, or by the neutralization of something else. Perhaps Ague is one of these.

And it is not repugnant to what we know of Ague to sup-

* Dr. Stuart, of South Carolina, has attempted to show that Quina acts by eliminating, or causing to be eliminated, Uric acid from the blood! On the other hand, Dr. Ranke has wished to prove that it diminishes the amount of Uric acid in the urine. (*Med. Times*, May 30, 1857.) These opposite theories may be safely left to neutralize one another.

pose, that there is in it a want of some natural material which would have, when present, the effect of checking the operation of the morbid agent. The fact of having had Ague once does not, as in the case of the Eruptive fevers, protect a man from the disorder thenceforward. So, in this sense, all persons may be said to be liable to Ague, and none protected from its assault. But it is not the case with Ague as it is with Syphilis and Small Pox, which diseases most persons inevitably catch, who are exposed to the virus for the first time in their lives. For, of a number of persons exposed to the same malarious influence, only a part take the disorder; some escape. It is generally found that those are most likely to take it who have been previously debilitated by any cause; so that we must suppose that the rest have in their blood some material which serves to prevent the working in it of the Ague-poison, which, apparently must enter it. It is not unlikely then that Ague may be cured by supplying the want of this material.

Coupling with this consideration those facts which have been previously stated, we may reasonably conclude that Tonics are Restorative, and not Catalytic in their action; that they supply, or cause to be supplied, a material wanting in the blood. How this material is enabled to resist the morbid influence of the miasm—whether it is by an antiseptic property, such as has been attributed to Quina—I cannot determine.

The argument respecting Quina, and the other Tonic principles of which it is the type, may now be thus briefly summed up. As their action is permanent instead of transitory, as they do not affect the nerves in the first instance, and the diseases in which they are used are blood-diseases, we conclude that they are Blood-medicines We next find that there is in that part of the Bile which is absorbed into the blood, a crystalline substance, bearing a resemblance in several important points to the bitter alkaloids. It is discovered by careful experiments, that Quina, when taken in moderate doses, is not excreted from the system, but retained in the blood, like its analogue Taurine. It being thus shown that Quina adds something to the blood, and it being granted that it cures certain disorders—a presumption is lastly established that these disorders are connected with some deficiency in the blood, which may be supplied by such an agent.

In this manner are established in detail the minor propositions (p. 137,) which, taken together, determine the operation of the bitter alkaloid to be that of a Restorative hæmatic. It is quite destitute of the poisonous and active properties of a Catalytic.

Having now done my best to establish the Proposition, as applicable to Tonic medicines, I may venture to bring forward a speculation concerning their action, which I would not wish to rate at higher than it is worth, and still less endeavour to demonstrate as a fact.

I have already made use of one of the principles of the Bile, for the purpose of showing that among the natural constituents of the blood there is a substance which chemically resembles a Tonic alkaloid, like Quina. This similarity admits of a further and more distinct application.

It is ascertained that many, if not all, of the diseases in which Quina and its kindred medicines are found to be of use, are connected with a derangement of the secretory functions of the liver. One of these diseases is the debility which is consequent upon Typhoid and other fevers. In these fevers the function of the liver is always more or less interfered with, though more obviously in some cases than in others. In strumous habits, in which generally bark is of signal service, and was very strongly recommended by Cullen, Fordyce, and others,—there is found commonly a peculiar degeneration of the liver, which has been ably described by Dr. G. Budd. This state is distinct from the fatty enlargement common in Phthisis, in the early stage of which disease Quinine is also very serviceable.

Quinine is often beneficial in Gout, in which the liver is always more or less deranged. (A celebrated nostrum, the "Portland Powder for the Gout," contained another bitter—Gentian.)

Turning to periodic diseases, we find that impaired hepatic functions are the rule, and the absence of such disorder the exception. This will be at once admitted in the case of Dysentery, and of the Remittent and Yellow fevers of the Tropics. It is also true of Ague. It seems even likely that the enlarged spleen may be partly caused by an obstruction to the circulation in the liver. This affection of the spleen is not uncommon in other liver diseases.

In Typhus fever both the spleen is disorganized and the liver deranged. It is observed in tropical countries that severe forms of remittent not unfrequently pass into continued fever, which seems to point to some analogy between the two. Ague even may pass into Typhoid fever. And Quina has of late been strongly recommended in the treatment of continued fevers in general.

Dr. Watson states that in New Zealand the biliary functions suffer so much in the intermittent which occurs there, that it is known among the inhabitants by the name of the "Gall-fever." (*Lectures on the Practice of Medicine*, vol. i. p. 793.)

Asiatic Cholera is considered by many physicians to be a kind of terrible intermittent, which seldom lasts beyond the second or cold stage. The secretion of bile is completely arrested during the continuance of the rice-water purging. Quina has been tried in Cholera, and the beneficial results have been sufficiently marked to encourage us to give it a more extensive trial in the event of another visitation.

Let us now place in conjunction with these facts, the similarity which has been pointed out between the bitter vegetable principles, and one of the chief constituents of the re-absorbed bile. Quina and others resemble in many points a certain principle in the bile; they tend to cure certain diseases, and these diseases depend on deranged hepatic functions. Does not this suggest the possibility that they may be of service by actually forming the above principle, or by supplying its place in the blood? It is possible that such bodies as Quina and Cinchonia may be able to fulfil the function of Bile in the blood by remaining as they are, without even changing at all.

It is just possible that the presence in the blood of the bile-product, the supply of which has been cut off by the hepatic disease, might have prevented the continual action of the Ague-poison.

There is another fact which gives additional probability to such an idea. Another remedy of a different kind has been used in all the diseases in which Quina is admissible, proving in some cases superior, and in other instances second only to it in its beneficial action. This is Mercury; used in remittent and yellow fevers; of the first importance in dysentery; employed by Dr. Baillie in Ague, and pronounced by him to be in some cases superior even to Quina. In small doses it is frequently of use in cases of debility and scrofula. And Mercury is a Cholagogue; *i. e.* an agent which is known to have the effect of promoting the secretory function of the liver. Thus we may conceive that Mercury, not given in excess, or to salivation, may operate in a different way to produce the same end as Quina. One explanation would suffice for both.

If this connection between Tonics and the Bile were actually established, then we should be enabled to explain a matter which would otherwise seem difficult to understand;—how it is that small doses of Mercury may sometimes act as Tonics, though we know that the ultimate action of this medicine, like that of other Catalytics, is to deteriorate the blood. Even in scrofulous and enfeebled cases, small doses of blue pill or of Calomel are often signally useful; and not prejudicial, as is sometimes stated by those who confound their application with that of Mercury given in salivating doses. Under such a course when judiciously enforced, we may see the dilated pupil contract to its normal size, and the pale enervated countenance become rosy and lively, and feel the weak compressible pulse to become hard and firm. Perhaps Mercury in such a case may be indirectly tonic, by restoring to the blood the natural tonic principle of the bile.

It will be conceded that it is a merit in a theory, when it succeeds in explaining at the same time a number of different things in a plausible way. It seems that the above hypothesis of the connection of Tonics with Taurine, or some such element of the Bile, is capable of so doing. I am far from asserting that it is proved, or from supposing that it is at all likely to be so in the present state of our knowledge of the subject; but I think that, if not evidently true, it appears at least reasonable.* And it may be observed, that even should this idea be completely overthrown, there would still seem to be left ample evidence to prove that Quina and other vegetable bitters act on the blood on the restorative principle,—though in what exact way is uncertain.

Tonics are among the most useful of all medicines. And it

* Dr. Easton of Glasgow, in a second paper on the Elimination, Catalysis, and Counteraction of Poisons (*Glasgow Medical Journal*, October, 1858,) accuses me of unusual speculative boldness in my advocacy of the above theory. He regrets that "a treatise, otherwise so excellent and complete, should still continue to be disfigured, in a second edition, by a manifest blemish." I have seen as yet no adequate reason for resigning what seems to me to be the only possible explanation of a very difficult question. His ground for rejecting it is, that Taurine is not present in healthy bile, but is only an educt produced in the laboratory of the chemist. As I conceive that this is a misapprehension of the case, I am constrained to dismiss the objection as unsatisfactory.—(*v.* p. 170.)

is certainly not the least of their recommendations, that we can seldom or never do harm by their use. They are remedies, but not poisons. Many a man has been killed by Opium, many a constitution ruined by Mercury, but it has never been known that Quinine has done the one or the other. I am hardly disposed to go all lengths with the physician who wrote a book* to prove the following syllogism:—All diseases are varieties of Ague; Quinine cures all varieties of Ague; therefore, Quinine cures all diseases. But I think there is little doubt that it cures, or tends to cure a great many diseases. These diseases may be chiefly summed under two heads; the first, comprising many varieties of simple Debility; the second, Ague, and all intermittent and remittent disorders. This latter class of periodic affections is the one over which these medicines exert most control. It is on this account that they have frequently received the title *Antiperiodics*, a term which I wish to apply solely to medicines (as Arsenic) which cure Ague on the catalytic principle, restricting at the same time the word *Tonic* to the bitter principles of vegetables. Connected with intermittents are the Remittent and Typhoid Fevers; over these Quina exerts also a curative influence. It seems likewise to possess some control over Cholera, which is considered by many to be a kind of Intermittent. To this list may be added some others, already mentioned in the course of the discussion, which Tonics tend to benefit, if not to cure. These are blood diseases, and are generally connected with hepatic derangement. (See above.) The chief are, Gout, Rheumatism, Dyspepsia, and Scrofula. (*v.* Quinine, in Chap. IV.)

* "*The Unity of Disease,*" by Dr. Dickson.

ORD. V. CHALYBEATES.

(Iron. Protoxide, Sesquioxide, and Sesquichloride of Iron. Salts of Iron:—viz. the Carbonate; Protosulphate; Persulphate; Phosphate; Pernitrate; Peracetate; Ammonio-citrate; Potassio-tartrate. Vinum Ferri. Chalybeate Waters.)

Most of these substances are readily soluble in water. Steel wine contains a Tartrate. The insoluble oxides are doubtless dissolved by the aid of the acid of the stomach; and we find that both are most active when given in the form of hydrate, which is most easily soluble in such a menstruum. Metallic Iron itself is sometimes given, in a finely divided state (*pulvis ferri.*) In that condition it rapidly combines with oxygen, and is more or less dissolved by the gastric juice. Thus Chalybeates are capable of being absorbed; and they no doubt are absorbed. They have been detected in the blood, and discovered in the secretions of urine and milk.

Being in the blood, they act by an influence which they exert upon it; for they are wanting in all the characters which distinguish nerve-medicines. They are never sudden in their action, and the effect which they produce is lasting.

Iron is found naturally in the blood; and the substance in which it is found is that which constitutes the colouring material of the red corpuscles. This is called Hæmatosin. It has been asserted by some that the red colour of Hæmatosin does not depend upon the iron which it contains. But, however improbable this may be, it matters not here whether it be proved so or not; for it is sufficient that it is ascertained that Iron is essential to the chemical constitution of this red matter. Without Iron, Hæmatosin could not exist, any more than Albumen could continue to be Albumen, when deprived of nitrogen.

According to the analysis of Mulder,

$$\text{Hæmatosin} = C_{44}\, H_{22}\, O_6\, N_3\, Fe.$$

It is a very peculiar body, and apparently an essential and most important constituent of the blood; for when it is deficient, as evidenced by the paleness of the tissues in Anæmia, the whole system suffers materially, and great and general debility is produced.

The result of the administration of an Iron medicine is the restoration of this wanting colouring matter. For if the blood be analyzed before and after its employment, it is found to have undergone a remarkable change, most particularly in the quantity of Hæmatosin which it contains. A case in illustration of this is given by M. Simon, of Berlin. (*Anim. Chem.*, vol. i. pp. 310, 313. *Syd. Society.*) The solid constituents of the blood, in a case of Chlorosis, had increased, under the use of iron, from 128·5 to 193·5 in 1000 parts; the Globuline from 30 to 90; and the Hæmatosin from 1·43 to 4·59, in the same amount. It is probable that the increase in the Hæmatosin is the first change; that this then improves the condition of the blood-corpuscles, increases their number, and through them betters the condition of the blood, and of the system generally.

In a case which came under my own observation, the blood of an anæmic girl was found, before the use of iron, to contain only 50 parts of globules in 1000, instead of 120, the normal average. The Ammonio-citrate of Iron was prescribed, in five-grain doses, three times a day. After it had been continued for a month, the blood was again analyzed, and the amount of corpuscles found to have increased to 76 parts. After another month, they had reached to upwards of 100 in 1000 parts of blood. In the meantime the appearance of the patient had improved immensely.

Chalybeates have thus a most immediate and obvious effect in restoring to the blood this wanting Hæmatosin. As the exact chemical condition of the Iron in Hæmatosin has not been discovered, so also the precise changes which Chalybeate medicines have to undergo, before they can supply this deficient material in a fit and proper form, are not known. Mialhe considers that an albuminate of the peroxide of Iron is formed in the blood, and that this is the basis of the red globules. All the known soluble compounds of Iron, except the Ferrocyanide and Ferridcyanide of Potassium, possess this restorative power.* In most Chalybeates the Iron acts the part of a base; but in some, as the Ammonio-citrate and Potassio-tartrate, it exists in a peculiar condition, and cannot be precipitated from their solutions by Ammonia. The water of Chalybeate springs generally contains a Carbonate of Iron, held in solution by an excess of Carbonic acid. The same salt is contained in the compound Iron mixture and pill of the Pharmacopœia, when these are rightly prepared.

Bouchardat has maintained that Iron is only efficient when in the state of protoxide, and that the persalts are of no use except as astringents. This is quite opposed to our common experience of the value of the Sesquichloride, and Citrate of the Peroxide. Conceiving it quite impossible for so unstable a compound as the protoxide of Iron to escape the action of the oxygen in the blood, I believe that however it may enter the body, the Iron must sooner or later be reduced to the state of Peroxide.

When the Iron has entered the system, it is not necessarily excreted again from it, because it is not unnatural to the blood. To ascertain whether Iron given in small quantities is excreted by the kidneys, I have tested the urine of a pa-

* Mialhe accounts for this exception on the ground that these salts are not precipitable by the alkalies or their carbonates. Thus the iron is not brought into the state of free oxide, and cannot combine with albumen. But the double salts with ammonia and potash and the vegetable acids are similarly unprecipitable, and yet are most useful as Chalybeates. The Ferrocyanide and Ferridcyanide, unlike the other compounds of Iron, pass directly into the urine.

tient who had been for some time taking thirty drops of the Tincture of the Sesquichloride twice a day, but have been unable to detect in it any trace of the metal. M. Quevenne has also discovered that when Chalybeates are taken in considerable doses, little or none of the Iron can be detected as passing out in the secretions. (*Journal de Pharmacie et de Chimie*, 1854.)

But when given in still larger doses, Iron passes off by the urine * and by other secretions. According to Dumas, Mialhe, and Quevenne, it is partly excreted by means of the hair, the growth of which it stimulates, and which contains it in considerable quantity. Some portion may be excreted by the intestine, and combine in the cavity of the bowel with Sulphuretted Hydrogen. The resulting Sulphuret communicates to the fæces a characteristic black colour. The cause of this colour was ill understood, until pointed out by Berzelius.

When the salts of Iron pass through the glands, they generally prove to be more or less astringent. The Chloride and Sulphate are most so; and they will thus be mentioned again under the head of Astringent medicines. The tincture of the Sesquichloride has obtained the reputation of being diuretic. But this constitutes no exception to the rule of its being astringent; for this diuretic power is owing to a peculiar ether, formed with the spirit by an excess of hydrochloric acid used in the preparation of the tincture.

The beneficial action of Chalybeate preparations is considered by some writers to be inversely proportioned to their astringency. This is at least true so far as this—that the astringent or irritant preparations of Iron cannot with impunity be given in so large a dose as the others. Whatever compound or salt of Iron be selected, it should be administered within half an hour after a meal. If a soluble salt, that by being mixed with the food it may be prevented from causing

* Berzelius, *Traité de Chimie*, t. vii. p. 402.

irritation by sudden contact with the coat of the stomach; if an insoluble Chalybeate, that it may meet with such an outflow of acid gastric juice as may be able to reduce it to solution.

I believe Iron to be simply and solely a Restorative remedy. By improving the condition of the blood, it appears similar in action to Tonics; but it is not a true Tonic, for neither in debility nor in Ague is it of any service, unless there is at the same time Anæmia. In some cases, even of Anæmia, Iron will not effect a cure. This must be because the appropriative power of the system is so weakened and degenerated, that it is incapable of consigning even this needful substance to its proper destination.

Anæmia is the one disease in which iron is of use. Purgative medicines form a valuable adjunct to the treatment in most cases. Dr. G. Owen Rees has suggested that they may be of use by removing some of the water of the blood, so that the corpuscles, being then shrivelled by exosmosis of their contents, may be in a fitter condition to absorb the "ferriferous chyle." And yet, if so, the drinking of a single glass of water would probably be sufficient to swell out the corpuscles again, and thus put a stop to the process. It is just possible that a Cathartic may be serviceable by purging away from the blood some effete matters, as Sulphuretted Hydrogen, formed by the continual decomposition of the tissues, which would have hindered the operation of the Chalybeate in the blood, by decomposing it.

The use of Iron may, I think, be summed up by saying that it cures Anæmia. In this way it may benefit, and sometimes cure, other disorders, in which Anæmia is apt to be a prominent symptom. Such are Amenorrhœa, Scrofula, Cancer, chronic Ague, Hysteria, Chorea, and Bright's disease of the kidney. To these we may add Erysipelas of a low kind, which is sometimes associated with Anæmia. But it seems that it can never be used advantageously in these disorders, when they are unattended with Anæmia; nor even then is it to be preferred to the other remedies specially appropriate in each case, but ought rather to be conjoined with them. Cancer, and granular kidney disease, may perhaps be alleviated, but are seldom cured. In Chorea, Arsenic or Quinine may be used, with or without Iron. Aloetic purgatives may be advantageously conjoined with Chalybeates in Amenorrhœa and Hysteria. Their use may be accompanied by cold affusions, or by some antispasmodic stimulant. In Scrofula the Iodide of Iron affords us a valuable double remedy.* In chronic cases of Ague, when accompanied with Anæmia, as is often the case, Iron may be prescribed with advantage.

In general Anæmia, an occasional purge, a generous diet, with good air and exercise, should be combined, if possible, with the Chalybeate treatment.

ORD. VI. SOLVENTS.

(*Antilithics.*

The mineral Alkalies, their Carbonates, and neutral salts with vegetable acids. Biborate and Phosphate of Soda. Benzoic and Cinnamic acids.

Antiphosphatics.

Mineral and vegetable acids. Sour fruits.)

Of all the fluid secretions, the secretion of Urine is perhaps the only important one which cannot cease to be fluid without

* When Iodide of Iron is taken, the Iodine passes out in the urine, but either none of the Iron leaves the system at all, or only the merest trace can be discovered in the urine. Quevenne found that, after administering fifteen grains of Iodide of Iron, the Iodine appeared in the urine in ten or fifteen minutes; in forty-eight hours three-fourths had been excreted in this way; but during the same period only a trace of Iron was discovered in that secretion.

This well illustrates one important difference between the catalytic (iodine) and the restorative (iron.) The former must be excreted; the latter may be assimilated.

immediate damage to the system. The deposit of solid matter from this secretion is dangerous, because tending to the formation of a solid calculus in the kidney or the bladder, in neither case easily extracted, and acting like a foreign body in these sensitive organs. This Urine, naturally clear and limpid, contains in it several substances which are by their nature insoluble, but are held in solution by certain other materials. But in some morbid states these latter materials may be wanting, or else the insoluble bodies may be secreted in such quantity that the solvent material is unable to hold them in solution. In such instances, these parts of the urine may either be separated by the kidneys from the blood in a solid state, or may be deposited from the urine after excretion or on cooling. They then fall down in a crystalline or finely divided state, and constitute Urinary Deposits.

Solvents are medicines which are employed to hold these insoluble substances in solution, where there is not enough of the natural solvent material in the system. They are medicines which tend, after being absorbed, to pass out of the blood into the urine. Although we are ill-informed as to the nature of the ordinary urinary solvents, yet it is evident that they must be present, because substances which are by their nature insoluble occur in healthy urine. And it is also evident that these medicines are able to supply their place; for, after one is given in a case of urinary deposit, this latter disappears, at the same time that the solvent remedy may be detected chemically in the urine.

In this, the last order of Restorative Hæmatics, a number of apparently dissimilar medicines are grouped together, all of which agree in this point of their action.

The deposits in which solvents are appropriate are termed respectively Lithic and Phosphatic. Among the first are comprehended Uric acid (also called Lithic,) Urate of Ammonia, and the more rarely occurring Urate of Soda. In the second set are comprised the Triple Phosphate of Ammonia and Magnesia, and the Phosphate of Lime. These deposits are each known by their peculiar form under the microscope.* They may easily be separated from the urine, when in any amount, and tested chemically. The Lithic deposits (*i. e.* Uric acid and Urate of Ammonia) are entirely dispelled by a red heat, and are soluble in Alkalies. The Phosphatic deposits leave an earthy residue when heated, and are soluble in acids. When thus held in solution, the former are precipitated by an acid, the latter by an alkali, because by such a reagent the solvent is neutralized in each case.

Now the circumstances which may cause these deposits are mainly of four kinds. (1.) A wrong in the diet. (2.) An error in the normal reaction of the blood, causing these matters to be deposited, *without being themselves in excess.* (3.) Thesu ppression of another secretion. (4.) A fault of some process of assimilation or secretion, causing *an absolute excess* of these constituents of the urine.

Urinary sediments may be caused by slight variations in diet. Excessive indulgence in animal food or in wine may cause an over-secretion of Lithic acid. Sour drinks may cause a similar deposit, by rendering the urine acid; and sweet fruits, containing vegetable salts of the alkalies, may produce a phosphatic sediment, by rendering it alkaline. Such cases may be remedied by an attention to diet.

Again, deposits may be caused by an excess of acid or of alkali in the blood, which excess is excreted by the kidneys, and causes a lithic or phosphatic gravel, without an excess of Lithates or of Phosphates in the urine. Whatever

* A deposit of Oxalate of Lime occurs sometimes. It is seen in minute octahedra; but is rarely in sufficient quantity to be distinguished by chemical tests. It does not come within the influence of Solvent medicines. But if, as Dr. Rees supposes, the production of Oxalic Acid is only an aberrant symptom of the lithic acid diathesis—then antilithics might reasonably be recommended in Oxaluria, as indeed they are.

be the condition of Uric acid in Urine, it is certain that it is held in solution by some matter of an alkaline nature.* When this alkaline matter is neutralized by an acid, the Uric acid precipitates. This may perhaps be caused in Rheumatic fever by an excess of Lactic acid. The Phosphates are held in solution by Phosphoric acid, or by that matter which gives to healthy urine its slight acid reaction.† An excess of alkali in the blood, which may probably occur in Typhoid and low fevers, will cause their precipitation. Or the alkali may be formed in the bladder by the decomposition of the urine. This may occur in inflammation of the bladder, or in retention of urine caused by paraplegic paralysis.

In some cases of an excessively acid secretion in the stomach, as may occur during the presence of *Sarcina ventriculi*, there does not seem to be enough acid left in the system to maintain the acidity of the urine. This then is apt to become alkaline, and may deposit Phosphates.

In such cases there is no absolute excess of the deposited matter; but it is in relative excess, for the substance which should properly dissolve it is overcome or neutralized by a reagent of an opposite nature. Acids and alkalies have already been mentioned as efficacious in these instances; the former in phosphatic, the latter in lithic deposits. They directly neutralize the disturbing cause; the alkali, or the acid. They are not in such cases truly solvents; they do not them-

* Some suppose that this acid occurs in healthy urine in a free state. It is more commonly thought to exist as Urate of Ammonia. Lehmann states that it is found as Urate of Soda. Others imagine that it is held in solution by means of Phosphate of Soda.

† This acid is ascribed by some to Urate of Ammonia, which is to a small extent soluble in water. Others consider that it is due both to this and to Phosphoric acid, which is the opinion of Dr. Prout and Dr. G. Bird. Others attribute it to Lactic acid, which is stated by Berzelius, Lehmann, and Simon, to exist in healthy urine. Some consider the acid to consist in a Superphosphate of Soda. Liebig supposes that it is due to Uric acid, held in solution by the common Phosphate of Soda. He also considers Hippuric acid to be an invariable ingredient in healthy human urine.

selves hold in solution the insoluble materials, but they set free something else that shall be capable of doing so. (*v. Acids; Alkalies.*)

A suppression of the secretion of the skin causes a lithic deposit in some cases, as in a common "cold." For the perspiration contains a free acid, probably lactic or butyric; and when it is suppressed, the secretion of this acid is thrown upon the kidneys, and the urine is rendered more acid than naturally. The obvious indication in the treatment is to restore the function of the skin, as by warm baths, diaphoretics, etc.

It is in the case of urinary deposits produced in the fourth way that true Solvents are appropriate.

From some morbid condition of the system, it happens that these insoluble constituents of the urine are secreted *in absolute excess*,—in a larger quantity than in health. Now the system labours to excrete them in solution, even when in excess; and often succeeds in doing so. But frequently this cannot be done, it being impossible for a sufficient quantity of the solvent material to be formed out of the blood. There is then a deposit in the urine.

We have seen that when such matters are deposited because in relative excess, the only fit mode of treatment consists in the administration of an acid or an alkali, which shall neutralize the morbid reaction of the blood. Such a case is rare; but these cases of absolute excess are much more common. There are two ways in which we may treat them; we may adopt either curative or palliative remedies. We may aim at the cause of the disease, which is generally in the blood. An absolute excess of Lithates may be caused by dyspepsia, or by a gouty disorder. This is most surely controlled by a Catalytic medicine. (*v. Antiarthritics.*) An absolute excess of Phosphates may be caused by an organic derangement of the nervous centres, when it is very difficult to cure; or it may simply be due to great nervous excitement, hard study, or melancholia. Such cases should be distinguished from a mere alkaline condition of the urine, without absolute excess of Phosphates, and may often be cured by attention to the disturbed nervous functions.

Such a curative course of treatment aims at the primary cause of the deposit; but when we are unsuccessful in our attempt to control this, or when the excess of solid matter is so great as to be positively dangerous, we are then driven to have recourse to palliative remedies. These are Solvents; medicines which pass into the blood, combine there with the peccant matters, pass out with them into the urinary secretion, and hold them there securely in solution. Such an agent may often be advantageously combined with the Catalytic remedy, which tends to cure the systematic disorder. It is a blood-medicine. Its action is so far permanent, that it effects its object definitely, dissolving and carrying away a certain portion of insoluble matter. But as it also passes out itself, it requires to be frequently repeated, because the deposit continues to be formed, and demands each time a fresh portion of solvent. It obviously acts on the Restorative principle. The deposit should be excreted in a dissolved state, but is not. The remedy therefore supplies a want.

Water is the simplest and most efficacious of all solvents, and should in all cases of gravel be very freely administered. Bouchardat has remarked that great water-drinkers are never afflicted with stone. All the urinary deposits are, to some extent, soluble in water, although *comparatively* insoluble. Whenever the urine is of higher specific gravity than it should be in health, more water should be drunk. The average specific gravity of healthy urine is about 1·018.*

Acids and Alkalies are most important as solvents. They

* According to Simon, it is 1·0125; Becquerel makes it 1·017; Dr. Prout and Dr. Golding Bird, 1·020; Berzelius rates it still higher.

do not now act indirectly, as in the case before mentioned, but directly dissolve the insoluble matter. Acids dissolve a phosphatic, and Alkalies or their carbonates a lithic deposit, in the body, as well as out of it. Although the natural solvent may be neither an acid nor an alkali, but something else different in nature from these, yet anything that will rightly dissolve the deposit will be fit to supply its place. Any of the free Acids may serve to dissolve a precipitated phosphate. Hydrochloric is perhaps the best of the mineral acids, although Phosphoric has been recommended on theoretical grounds. Sulphuric is the least efficacious, because it does not always pass out in the urine. (*v. Chap. IV.*) Sour fruits, as Currants or green Gooseberries, may be useful in phosphatic cases; but ripe fruits have an opposite tendency. Acidulous drinks may be recommended, as Cider, Perry, and Rhenish wines. Of the free alkalies used to dissolve a lithic sediment, Potash is preferable to Soda, because it forms a more soluble compound with Uric acid. The Bicarbonates of the fixed alkalies are best, because least irritant. Bicarbonate of Soda is contained in Vichy water. The soluble Bicarbonate of Magnesia may be given with advantage. The Carbonate of Lithia has been recommended by Mr. A. Ure; but it is comparatively insoluble. The neutral vegetable salts of the alkalies, and sweet fruits which contain them, are equivalent to the Carbonates, because converted into them in the system, as has already been shown. They may be pleasantly administered in the form of effervescing draughts, in the formation of which the Carbonic acid of an alkaline carbonate is displaced by Citric or Tartaric acid.

The danger which attends the continual use of acids or of alkalies, particularly of the latter, is that their long employment may engender a condition of an opposite nature to that which they were intended to alleviate. An acid may at length cause a lithic deposit in the urine; or, still more frequently, an alkali may produce a phosphatic sediment. Their administration should therefore be conducted with caution.*

There are some other remedies which may be advantageously employed as solvents for Uric acid and Urates, whose use is not attended with this danger, and whose efficacy is a proof that the occurrence of a deposit in the urine is not a mere question of the preponderance of acid or of alkali in that secretion. The most important of these is the common Phosphate of Soda, first recommended by Liebig, who discovered that Uric acid was soluble in a solution of that salt.

If forty grains of dry Phosphate of Soda, seven grains of Uric acid, and fifteen of Hippuric acid, be dissolved in a pint of hot water, and to this solution two per cent. of Urea be added, a kind of artificial urine will be formed.

Biborate of Soda, or Borax, has also the power of dissolving Uric acid, and has been recommended in the treatment of lithic deposits by Bouchardat and Binswanger.

Mr. A. Ure has strongly recommended Benzoic acid in these cases. It passes out in the urine as Hippuric acid. (*v. Prop. VI.*) The amount of the deposit appears to decrease under the use of this remedy; but whether the formation of the Uric acid in the blood is prevented, as supposed by Mr. Ure, or whether it is not simply held in solution by means of the Hippuric acid, is not clear.† Dr. Golding Bird recommends

* Dr. Bence Jones considers that Alkalies may in some cases effect a radical cure of the lithic acid diathesis; that by combining with Lactic acid in the blood, they tend to promote its oxidation into Carbonic acid and water, and thus free the system from excess of acid matter. He recommends the following rules: so long as any red crystals of Uric acid are deposited from fresh urine kept for twenty-four hours in a glass vessel, the dose of alkali is to be continued or increased; the sooner such crystals form, the larger is the dose required, the largest of all being necessary when the red sand is formed in the bladder; but when no crystals at all form during the above period, the alkali must be stopped.—(*Lecture in Med. Times and Gaz.*, Mar. 25, 1854.)

† Benzoate of Soda is recommended by Bonjean on the ground that it has the power of *converting* Uric into Hippuric acid.—(*L'Union Médicale*, Paris, Sept. 1856.)

also Cinnamic acid, which is contained in cinnamon water, and in the balsams of Peru and Tolu. It resembles Benzoic, and undergoes the same change into Hippuric acid. The salts of these acids possess a similar power.

Diuretics in general are useful in all cases of urinary deposit, for they increase the quantity of the fluid part of the urine. It is observed by Dr. Prout that healthy urine is the best solvent that we are able to supply.

When solvent remedies are employed for the purposes above mentioned, they not unfrequently fail altogether; and, as has been already observed, they require, even when successful, to be perpetually administered, or else the deposit will recur. For the Solvent passes out along with each successive quantity of the Lithic or Phosphatic matter that is formed and excreted.

A radical cure of such deposits can only be effected by a medicine that shall counteract the morbid process by which they are continually produced. This can seldom be done by a Restorative, but requires a Catalytic medicine. Such remedies we must presently consider. (*v. Antiarthritics.*)

Thus are concluded the six orders of Restorative medicines; all of which are seen to agree together in some common characters.

When a disease depends on the want of some material in the system, then it admits of being cured by a Restorative, which, in the theory of its action, is the simplest of all known medicines. And when a morbid process results in a diminution of the amount in the blood of some necessary constituent, then also may a Restorative be of use in alleviating the consequences of such a disorder; or may even effect a cure, when the morbid process has ceased, and left only its results behind it.

But when the *materies morbi* is still working in the blood, a radical cure can only be effected by a Catalytic medicine, which shall be capable of meeting it there, and of counteracting its noxious influence.

Some Restoratives are also included among Catalytics, from a regard to a different phase of their action. The most important of these are Alkalies, which are of use in general inflammation, and also in Scrofulous and Scorbutic diseases, acting in a way that is at present but obscurely explained.

When the *modus operandi* of a medicine is obscure, but when it is apparent that it has the power of counteracting a disease, I have preferred to place it among Catalytics, rather than to include it with Restorative medicines. But there are not many cases in which we are thus left in doubt.

The diseases curable by Catalytics are all evidently produced by an active morbid agency. Those which are treated by Restoratives are just as evidently remediable by the artificial supply or substitution of some one or more of the elements of the blood.

CATALYTICS.

These constitute the second division of Hæmatic medicines. The above name is applied to them on the assumption that their operation in the blood results in the destruction or counteraction of certain morbid agencies. (*καταλύω.*)

The difference in action between this and the preceding division of blood-medicines has been stated at length in the remarks on Hæmatics in general. On recurring to Prop. VII., it will be seen that it is there stated—

"That others (medicines of the first class,) called Catalytics, act so as to counteract a morbid material or process, and must pass out of the body."

The action of the remedies in this division, which are the surest and most potent of all those that are employed in the treatment of disease, is involved in a greater degree of doubt

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and obscurity than that of any other class. Though there may be in some cases a certain dim explanation which we may catch hold of, and strive to fix or to render definite, yet in many instances there is not even so much as this. How can we, for example, by any of the common terms which are made use of to designate the actions of Mercury, of Arsenic, and of Iodine, express the peculiarity of their influence over Syphilis, Lepra, and Scrofula, respectively? Does it not seem better to confess our ignorance, and to say that all we know for certain is that these remedies have the power of antagonizing certain diseases?

Having done this, we may afterwards try, if we can, to invent for this action a theoretical explanation. Our arguments and theories will not affect the fact, nor will they lead us into danger, if we have first laid down the truth, however incomprehensible, as the only secure foundation, in such a manner that it shall be incapable of being disturbed by the flimsy superstructure. Some philosophers have erred in this; that they have first, with much pains and labour, erected an airy fabric on a basis of incontestable truth,—but subsequently, relying too much on that which they have themselves raised, they have commenced to pull up the blocks on which it was founded, and have thus brought the whole speculation tumbling to the ground in ruins.

Considering then that the action of Catalytic medicines in each disorder is of a special and peculiar kind, which I think will not be denied, I have grouped them in orders which are named according to the several morbid states in which they are employed.

CATALYTICA.

Ord. 1. Antiphlogistica.
Ord. 2. Antisyphilitica.
Ord. 3. Antiscrofulosa.
Ord. 4. Antiarthritica.

Ord. 5. Antiscorbutica.
Ord. 6. Antiperiodica.
Ord. 7. Anticonvulsiva.
Ord. 8. Antisquamosa.

The medicines of the first order are employed in inflammatory disorders generally, and possess an influence over the process of sthenic inflammation, however first produced. The second order contains those that are used in the several forms of Syphilis. The third, those that are employed in Scrofula. The fourth, those that are found to be useful in the cure of painful affections of the joints, as Gout and Rheumatism; and also of Oxaluria, Lithiasis, Diabetes, and other disorders of secondary assimilation. The fifth order contains those that are useful in Scurvy. The sixth, those that are employed in Ague, Remittents, and other periodic disorders, on the Catalytic principle. The seventh, those used in convulsive disorders. Lastly, the eighth, those that are capable of curing Lepra, Psoriasis vulgaris, and some other skin diseases.

The action of these medicines being much more obscure than that of Restoratives, I shall therefore have less to say about them individually, and shall not go so much into particulars. That part of Prop. VII. which refers to Catalytics may be divided into the following minor propositions:—

m. p. 1.—That they act in the blood, and that their effect is permanent.

m. p. 2.—That each of itself tends to work out a peculiar operation in the blood.

m. p. 3.—That the diseases in which they are used depend on certain morbid materials or actions in the blood.

m. p. 4.—That the result of the action of a Catalytic medicine is in some way to neutralize or counteract some one or more of these morbid processes.

m. p. 5.—That these medicines are all unnatural to the blood, and must at length pass out of the system.

It might seem at first as if the first, fourth, and fifth of these minor propositions would alone suffice to include the original affirmation. But a medicine may act in the blood, and may counteract a disorder; and yet it may counteract the disorder in some other way than by acting in the blood. It is necessary further to prove the disease to be a blood disease. And the evidence of counteraction will be rendered stronger if we can prove that the medicine employed is itself capable of setting up in the blood some peculiar process,—of causing in it a change of some special kind. For, were it not to do so, we could hardly understand how it could meet the requirements of one case more than of another, or how it could at all arrest an active process in that fluid over which it exerted itself no particular influence. And this thing, which is laid down in the second minor proposition, can, I think, be proved in the great majority of instances.

Before proceeding to the separate discussion of the orders of Catalytic medicines, it would be better that some remarks should be made upon the remedies of this division taken collectively. And we will, in the first place, consider some of the statements ventured by authors respecting this kind of medicines; as a comparison of these should aid us in the discovery of the truth.

But in referring to the opinions that have been advanced on the action of this group of medicines, our task is rendered comparatively easy by the fact that a great number of writers on Materia Medica have failed to recognise them as a body. It may seem strange to one who has reflected on the subject, but it is nevertheless true, that the majority of authors have taken no notice whatever of medicines acting in the blood, with the exception of Acids and Alkalies, which are grouped by some as Chemical remedies. All other medicines have been generally arranged under the two great and ill-defined heads of Nerve-medicines and Eliminatives. I cannot find it possible, by either of these terms, to give any idea of the real action of the many important agents which I have included in this division.

It would seem that it has been generally supposed that medicines—bodies of active properties, and more or less peculiar construction—are able to enter and to pass through a fluid which is still more complicated and changeable in nature than themselves, yet that while so doing they produce no impression upon it, but proceed passively to the solid tissues, or quietly pass out of the body, without ever leaving behind them any trace of their action.

Certain writers have made some amends by including in their arrangements a class termed Alteratives. But even then they have not unfrequently laid it down as a rule that they produce, in the first place, an impression on the nervous system, and that this has subsequently the effect of altering the manifestations of vital force. How varied and peculiar in nature must these nervous impressions be, to account for actions which are often so widely different!

The medicines thus grouped as Alteratives correspond very nearly with my division of Catalytics. The permanency of their effects, and the fact that the disorders which they cure are blood-disorders, will sufficiently stamp the character of the operation of these remedies.

In many works, as in those of Dr. Duncan, of Dr. A. T. Thomson, and more lately, of Drs. Ballard and Garrod, the existence of a class of Alteratives or blood-medicines is not even recognised or alluded to.

But in the learned classification of Dr. Pereira blood-medicines hold an important place. All except Chalybeates are grouped together in a sub-class, called Spanæmics, because they tend to impoverish the blood. In addition to those which I have named Catalytics, there are here the acids and alkalies. It is true that all these medicines, after long use, impoverish the blood, which, indeed, suffices to prove my first point—viz.: that they act in the blood, and that their effect is permanent. But Dr. Pereira has founded his classification on the physiological action of medicines, and not on their therapeutical uses, which form the basis of mine. Thus he takes no notice of the questions of what their ultimate destination may be, or what their primary *modus operandi;* whether they have to remain in the blood, or to pass out of it; and whether they can act by supplying a material to it, or by neutralizing a material in it. The subsequent statements which Dr. Pereira has chosen as the basis of his subdivisions, founded often on therapeutical action, seem in certain cases to be somewhat problematical. Thus he calls Acids "adipsa," or thirst-quenching, which very imperfectly expresses their action. Alkalies are grouped with Salts, Iodine, and Sulphur, under the general title of "resolventia seu liquefacientia," *i. e.* resolvents, or liquefacients, which involves an assumption that some might be inclined to dispute. The title of Spanæmics, applied to the whole, though unobjectionable in a classification which is founded upon their ultimate action in health, would be quite inappropriate in an arrangement like mine, which has to do with their influence in the cure of diseases. For our object in making use of such agents is not to impoverish the blood, but to obtain such a manifestation of their power as shall suffice to neutralize the noxious agent, and no more.

Dr. A. Billing (*Principles of Medicine, 5th edit.* pp. 70–75) considers that Mercury, Arsenic, Colchicum, and all the medicines which have been called Specifics, are not in fact so, but that they are capable of subduing different kinds of inflammation by causing contraction of the dilated capillary vessels. This explanation has certainly the charm of simplicity, but not, in my opinion, the merit of truth. Dr. Billing supports this argument by instancing the number of remedies that have been used in Syphilis, and considers that they must all operate in a similar way, both in this and in other disorders. Yet are all these medicines of use or advantage in Ague, in Lepra, in Chorea, and in Scrofula? But why is it not so, if all act in the same way? Their several actions should exhibit no difference in kind, but only in degree. It is the opinion of the same able authority that Mercury and Iodine diminish morbid growths by starving them; that they cut off the supply of blood by contracting the capillaries in the same way as in other cases. But why then can we not thus remove a fatty tumour, a true exostosis, or a malignant growth? We are seldom able by such means to reduce the size of a tumour, unless it depends on a blood-disorder, as Syphilis or Scrofula. The wide distinctions and the shades of difference which exist between the operations of these several medicines are surely too many and too serious to allow us to account for them all by one explanation.

But we may put aside general arguments, and appeal to facts. In the first place, it is very far from being proved that in all these disorders the capillary vessels are dilated. But let us even admit that it is so proved, and we are not then nearer to the establishment of the above hypothesis. For is the action of any medicinal agent on the capillaries constant in character?

Mr. Wharton Jones, in his Astley Cooper Prize Essay, states that he has found the effects of medicinal solutions on the capillaries in the web of a frog's foot to be very various. For even a solution of Sulphate of Copper has been known to cause dilatation, and one of Atropia to produce constriction; though the former is an astringent, and the latter a paralyzer. So that the vessels are not nearly so much under the influence of such agencies as Dr. Billing would seem to imagine. In these experiments the solutions were concentrated, and applied directly. But in the cases in point we might have two or three grains of Iodide of Potassium, one-tenth of a grain of Arsenite of Potash, or one-twentieth of a grain of Bichloride of Mercury, diluted down by about twenty pounds of blood, and extended through many miles of capillary tubes! And if simple contraction of the capillaries were required, surely Astringents, which are known to effect this, should be the most useful of all these medicines. But we do not find it to be so. Further, this idea must include a virtual denial of the causation of blood disorders by special morbid agencies.

Such are the grounds upon which is founded a denial of the existence of specific medicines,—*i. e.* of remedies which are of particular or special use in one or more disorders.* Is it reasonable to deny that Mercury is of particular use in Syphilis? That Iodide of Potassium exerts a special influence over secondary forms of the same malady? that Iodine and Potash are each peculiarly adapted to scrofulous cases? or that Colchicum will often stop a fit of the Gout when other Medicines have failed to relieve it? If we cannot deny it, we must admit such actions to be in some degree specific. To adopt this term is to a certain extent to confess our ignorance, and for this reason many have objected to it; but under the circumstances some confession of ignorance is becoming. The

* "The study of specific medicines is too much disregarded now. No doubt the hunting after specifics is a mark of ignorance and weakness in medicine, yet the neglect of them is proof also of immaturity; for, in fact, all medicines will be found specific in the perfection of the science."—*S. T. Coleridge.* In a certain sense I agree to this. All blood-medicines, when rightly applied, are of *special* use with regard to particular *diseases;* and all remedies of the other three classes are of *special* use with regard to particular *symptoms.* (*c·* p. 128.)

word is, however, decidedly objectionable, when it is misapplied to express the idea of some particular medicine being the only one that can be used in a certain disorder. For this is an exaggeration of the truth that may lead to very serious error.

The Catalytic orders have been enumerated above. On reverting to the list it will be found that their titles have one common commencement. The prefix *Anti-* involves a principle. These medicines produce certain actions which are *contrary* to diseased actions, inasmuch as they neutralize them, and cannot subsist with them. It is granted that in some cases the actions may appear similar in some respects. But this merely shows that they move, as it were, in the same sphere, for else one of them could not meet the other. However the operation of a medicine may sometimes seem to resemble that of a disease, it is always in effect contrary to it. The similarity is of a kind which does not concern us. An acid and an alkali are so far similar, that they may both produce heat when mixed with water, and both prove corrosive and destructive to organized tissues; but they are practically contrary, and when brought together they neutralize each other. I will now just indicate the manner in which the minor propositions are to be established, reserving the fuller consideration of diseases and remedies until afterwards.

Catalytic medicines act in the blood, and their effect is permanent. This is simply to affirm that they belong to the class of Hæmatics, to which Restoratives also belong. Of all that are named below, there are not any, except Colchicum and Antimony, that possess in any degree the action of nerve-medicines,—*i.e.* that exert a sudden and transient influence over the nervous system. I believe the sedative powers of these medicines to be quite distinct from their Catalytic influence. I shall attempt to show that each of them has a peculiar action of its own on the blood, even in health; which cannot be said of Restorative medicines. Of all these Catalytics two things are known. When they cure a disease, they do so definitely, so that it does not in general tend to return; and when they only alleviate it, the improvement effected is more or less permanent. In the second place, they are found to produce, after being long administered, a change for the worse in the blood, a diminution in the amount of Fibrine and of the red corpuscles. Thus they are blood impoverishers, when given in excess. These considerations alone, when combined with the proof of absorption—*i. e.* that they all pass into the secretions, and may be detected there—are conclusive as to the fact of their being Hæmatic medicines. We pass to the second minor proposition, which consists in the statement of a property that is peculiar to Catalytic Hæmatics.

Each Catalytic tends of itself to work out a peculiar operation in the blood.

This peculiar process, established by their presence in the blood, forms part of the known history of each Catalytic medicine. It will suffice to demonstrate this if I condense into as few words as possible the facts that are known on this subject, with respect to each of the orders of this division of remedies, as we come to consider them in turn.

For the present it may be remarked that the catalytic remedies are chiefly drawn from the mineral kingdom, and consist of metallic salts and other substances, which are poisonous when in large doses. They all have an action in the blood, in some cases, similar, in many, different, in most, distinctive. Antimony, for example, wastes the blood, at the same time that it affects the nervous system. Mercury attacks the plastic element of the blood with still greater vigour, produces a fetid material out of it which is rapidly eliminated, and may cause a peculiar rash. Iodine wastes the body, brings on a low febrile condition, and causes a rash. Saline medicines dissolve fibrine, and waste the blood. Alkalies do the same, and eliminate sulphur into the urine, combined with them in the form of sulphuric acid. Sulphur effects changes in the blood, inasmuch as it is found to combine there both with hydrogen and oxygen, and to carry them out of the system as sulphuretted hydrogen and sulphuric acid. Arsenic, Silver, Zinc, Lead, Copper, have many curious and peculiar blood actions. They deteriorate the blood, and cause eruptive disorders. They affect the nerves in a permanent manner, either by their own presence in the blood, or by the presence of the products to which they give rise. And so, as we pass through the list of Catalytic remedies, shall I hope to show that each Catalytic has a peculiar blood operation.

The divisions of Hæmatics differ in this: Restoratives act by being in the blood; Catalytics by working in the blood. All we have to do with the latter just now is to affirm (what we shall afterwards establish) this part of their action.

Each of these medicines works out a certain process or operation in the blood, and affects the condition of that fluid. But I am very far from believing that this known operation is in all cases the one by which they neutralize morbid poisons. This action is probably of a much more inscrutable character.

Before proceeding further, I may here take the opportunity of insisting again on the differences between Catalytic and Restorative medicines. Catalytics will even in health work out their peculiar process in the blood. Restoratives exercise in that case no particular influence. The latter may remain in the blood; their office is supply or substitution. Catalytics may not remain beyond a certain time; their office is counteraction. The system then labours to excrete them. Before passing out of the body, one or two, as Colchicum, may act on the nerves. In the moment of excretion, the majority act as Eliminatives. But some, as the metals used as Anticonvulsives, are astringent, and diminish secretion generally. Mercury, Antimony, and Iodine, are among the most important Eliminatives known. They act on all glands, but on some more than on others. Antimony is also a special sedative to the Vagus nerve, and as such exerts an important influence, which enables it sometimes to cut short the process of inflammation by depressing the action of the heart.

We arrive at the third minor proposition.

The diseases in which these medicines are employed are active blood diseases.

In most cases the correctness of this statement is universally admitted.

That Syphilis, Scrofula, Gout, Rheumatism, Scorbutus, Ague, and Eruptive disorders, are essentially blood-diseases—*i. e.*, that in each of them there is either a morbid material present in that fluid, or a morbid action going on there, which constitutes the chief wrong,—is so generally admitted, that it may be said to form a fundamental part of the science of medicine as taught at the present day. This disposes of six out of the eight tribes of diseases in question. In inflammation, the primary causes of which are various, we have one thing which always brings it within the sphere of action of a blood-medicine. There is an excess of fibrine in the blood, which keeps up fever, and tends to cause effusions.

Among convulsive diseases, some are purely nervous; others, as Hysteria, Chorea, and some forms of Epilepsy and Tetanus, are connected, as will afterwards be shown, with a peculiar blood crasis, and may be controlled by blood-medicines.

It will shortly be indicated more at length that there is in all the diseases controlled by Catalytic medicines an active wrong in the blood.

It having been once shown that the diseases in which Catalytics are used have each their essence in a process in the blood, the fourth minor proposition will not be difficult to establish, though in fact the most important of all.

The action of a Catalytic results in the neutralization or counteraction of one or more of these morbid agencies.

This may be considered to be already sufficiently proved. It is established by experience that these remedies severally counteract the diseases named. It is shown that they have an action in the blood; and the diseases which they cure will be proved to be blood-diseases. Then it is clear that if the former counteract the latter, and have no action on the nerves, they must do it by some agency in that fluid, over the particles of which both exert an influence. They are Catalytic Hæmatics; *i. e.*, medicines which, by an operation in the blood, are enabled to counteract disorders which depend upon active morbid agencies. This is all that can be positively affirmed of their mode of operation.

The fifth and last minor proposition relates to an important difference between these and Restorative medicines. The latter may remain in the system, for if they did not do so, they could restore nothing to the blood. But Catalytics cannot restore any thing, for they are generally unnatural to the blood. They must sooner or later be excreted.

Catalytics are unnatural to the blood, and must at length pass out of the system.

Of the list of Catalytics, the only medicines that occur as constituents of healthy blood are Alkalies, Salts of the alkalies and earths, Chlorine, and Sulphur. Of these, the Alkalies, and possibly also the others, are not unnatural to the blood when administered in small quantities, and may remain in the system and act as Restoratives, when there is a deficiency in the blood of similar materials. But even these substances, when given in large quantity, as is the case when they are used for Catalytic purposes, are unnatural to the blood, and must be excreted from it. With respect to the other Catalytics, they cannot any of them remain naturally in the blood, under any circumstances. Their very presence for awhile constitutes an artificial disease, and is only to be tolerated or recommended because it may serve to counteract a morbid action of a more serious and uncontrollable character.

The kidneys generally constitute the channel by which these Catalytics are removed from the blood. Most of them, in passing out, act as diuretics. From this we must perhaps except the salts of Lead, Zinc, and Copper. Doubtless some are excreted partially or entirely by the mucous membrane of the bowels, but this we cannot so readily appreciate. The circumstance that the astringents just mentioned are efficacious in diarrhœa seems to point to their access to the intestinal surface from the blood.

It has already been shown that these Catalytics are all soluble in some way in the intestinal canal, and that they are absorbed. (*Vide Prop. I.; Prop. II.*) All of them that can be detected by chemical means have actually been discovered in the blood. But the system will not, if it can be avoided, suffer them to remain there long. The glands are charged with the office of purging the blood of all morbid materials; and thus these substances pass out in the secretions; most particularly, as I have just said, in the secretion of urine.

Every one of the medicines of this division, enumerated below,—excepting perhaps Colchicum, which is difficult to recognise chemically,—has been detected in the urine by M. Wöhler, M. Orfila, and others. The Alkalies and Acids are combined, so as to form salts; the vegetable salts are decomposed; Sulphur has changed into Sulphuric acid; and the metallic bases are found to be variously combined; but all the fixed inorganic materials remain essentially the same, however altered in arrangement. Many of these medicines have been likewise detected in the secretions of other glands. The subject will be further discussed in the consideration of Prop. X., and does not immediately concern us now.

The minor propositions being established, will build up the major; but all that I have ventured to affirm of this group of medicines is, that they counteract morbid agencies by an operation in the blood.

Now, the mode of counteraction is not defined, because it is only in a few cases that we can even guess at it. In the majority of instances it seems inexplicable. We know that Syphilis is a poison in the blood. Mercury also is a poison in the blood. But why does Mercury antagonize and annihilate Syphilis? The case is the same with Scrofula and Iodine; with Lepra and Arsenic. It is very humiliating to be baffled when we have got thus far; when, led by the hand of Science, we have been conducted almost to the end of this interesting inquiry, to find that we are perfectly unable to take the last step, and thus to conclude our adventure.

When there is no disease, a Catalytic medicine may work out its own action in the blood, and produce a disease. But when there is some previous disorder, the working of the Catalytic may operate so as to counteract this already existing action, being so far similar to it, that it acts in the same department, and may thus occasionally produce by an accident like results; but being nevertheless, as we have seen, essentially contrary to it, because it neutralizes it.

Such opposite relations are met with even among natural diseases. Vaccination and Small Pox afford us an instance of the mutual counteraction of morbid processes. These poisons are alike in their operation. Dr. Fouquet, of Freiburg, has tried the effects of re-vaccination in Syphilis, on the inmates of a large military hospital, with great apparent benefit, as it is said. These poisons are unlike in their results. So are Ague and Phthisis; and persons who have had Ague are said to be less liable to Phthisis than others. Again, we find that one attack of an eruptive fever preserves the system in some way from the renewed operation of the same poison. In these morbid phenomena we find something of a parallel to the curious operation of Catalytic medicines in controlling blood-diseases; for I have shown that these remedies themselves are artificial blood-diseases.

Such ideas lead us on into the uncertain regions of speculation.

The idea that diseased actions may possibly be accounted for by supposing the existence of special *fermentations* in the blood, is by no means a new one. Inscrutable as these diseased actions themselves may be, yet we are enabled to recognise processes of a nature analogous to fermentation as going on in that fluid in health. Of such a kind probably are, the change of albumen into fibrine; the changes which take place in the starchy matters of the food before they can be oxidized into carbonic acid; and the changes that must occur in nitrogenous substances before absorption, as well as those that accompany afterwards the downward progress of the same materials, from living tissue into Urea and Uric acid, to be finally excreted from the system. It is a curious fact that nearly every known product of organic fermentation has been discovered in the human body in health or in disease. Lactic, butyric and acetic acids have been frequently found there. Dr. Heintz has lately added to these succinic acid, discovered in a hydatid cyst of the liver.

The production of many disorders by the access of a known morbid material, the working of that material on the particles of the blood after a special fashion peculiar to itself alone, and the gradual elimination of certain products, also peculiar to this one operation, are circumstances in which diseases bear an obvious analogy to processes of fermentation. The same remark applies to the working of Catalytic medicines.

It is then just possible that one of these medicines might produce in the blood a fermentation which should meet and neutralize the morbid fermentation; or that it might simply determine the latter in a different direction, and thus bring it to a desirable end. Acting in health so as to produce a morbid change, it might operate in disease by means of diverting into a right direction a change that is already going on in a wrong one.

But let us leave generalities, and descend more into particulars. Are we in a position to be able to indicate the actual nature of the changes which we thus assume to be probable?

The term Fermentation is used to express a change or series of changes of a special character, caused among the particles of a compound body, by the presence of a certain other body called a Ferment. There are two kinds of fermentation. In one the ferment itself is undergoing change, and impresses a similar change upon a substance which is analogous in nature to itself.* The process caused by contagious disorder would probably be of this kind. Just as the changing yeast forms and increases itself out of the fermenting dough, so does the virus of such a disease renew and propagate itself out of the particles of the blood.

The other kind of fermentation is simpler in action, but more incomprehensible in character. It is produced by mere contact, without any change in the ferment itself. Thus it is

* "The state or condition of formation or decomposition of a body, the state of change of place or motion in which its particles are, exerts an influence on the particles of many other compounds, if in contact with them. The latter are brought into the same state; their elements are separated and newly arranged in a similar way, and acquire the power of entering into combination, a power which they did not, under similar circumstances, previously possess."—*Liebig's Animal Chemistry*, vol. i. p. 149.

"It is not to be doubted that in addition to these physiological ferments (Diastase and Pepsine,) the economy may often enclose others of a specific and peculiar nature, and which, as the sources of abnormal chemical reactions, might be called '*pathological ferments*.'" (Mialhe, *op. cit.* p. 36.)

known to chemists that spongy platinum causes the combination of oxygen and hydrogen, and exerts generally a powerful influence over the affinities of gases and liquids, without ever itself undergoing any change. The influence of Emulsine, in causing, by mere contact, the Amygdaline in the bitter almond to resolve into Prussic acid and other compounds;* and that of Pepsine or of Ptyaline, in promoting the change of Starch into Sugar; is of this kind.

Considering that Catalytic medicines are not by their nature changing bodies, being mostly minerals, it is not likely that they could cause that kind of fermentation which requires that the ferment itself should be in a state of change. The influence of contact is the one which they would be most calculated to exert. I may remark that I have used the term Catalytic without any reference or allusion to this sense, in which it has been frequently employed, but merely as conveniently expressive of undoing or destroying. I would not wish, either in the terms or in the propositions which I have adopted, to assume for granted anything which is not proved, still less an idea which is purely hypothetical.

But it is not very unlikely that some of these medicines may act in a mode which is more or less analogous to an action of fermentation of the kind just described. They might then either cause change themselves, and by this means alter and destroy a morbid process somewhat similar to that which they themselves excite, or they might, by simple contact, be able to resolve this process into a natural direction. We have seen that when introduced into healthy blood, they invariably tend to produce a change in it which is productive of harm; but that when there is already an abnormal process going on there, their influence will effect the subversion or annihilation of this other process.

* This very change will take place in the blood, as has been proved by Kölliker. (*Allgemeine Med. Cent. Zeitung*, 1856.)

And there are certain physiological considerations that render such an idea still more intelligible and plausible.

It is to be remembered that the blood, in which we suppose such actions to go on, is not an ordinary chemical fluid, subject to common laws and influences, such as we may meet with out of the body; but a very complicated mixture, which is ever circulating and being maintained at a high temperature, and contains a number of compound organic bodies, each of which is liable to a series of varied metamorphoses. It is not a very potent agency which is needed to disturb the chain of conditions of one of those inconstant bodies which is thus continually performing the circuit of the system.

I may briefly exemplify the series of changes, simple but momentous, which an organic body is capable of undergoing, if I instance the combination of elements which constitutes Urea.

By bringing Ammoniacal gas in contact with the vapour of Cyanic acid, we produce Cyanate of Ammonia, a poisonous salt. This, when exposed for some time to the air, changes into Urea, which is isomeric with it, but comparatively innocuous. Urea, when heated, gives off Ammonia, and becomes Cyanuric acid. On again heating this, hydrated Cyanic acid sublimes. This, when brought in contact with water, becomes Bicarbonate of Ammonia. Two equivalents of Cyanic acid, uniting in one compound, produce Fulminic acid. This, if combined with the oxide of Silver or of Mercury, forms a compound which is caused by the slightest friction to explode with terrific violence. If to the elements of this dangerous acid be added those of two equivalents of Ammonia, we again have Urea, a substance which is continually forming in the body by the oxidation of some of the nitrogenous tissues. Urea with water changes lastly into Carbonate of Ammonia. These several compounds, alike or identical in their ultimate composition, are possessed of very different properties, whether regarded as medicinal or as chemical agents.

A similar set of changes may be produced among the elements of Uric acid, also an animal product.

Changes in some respect similar to these which are produced by the chemist are no doubt continually going on, or capable of being set up by various influences, in the circulating blood, which is at a heat fit for such processes; in which also is a considerable quantity of free oxygen, as well as soda, ammonia, and other elements, in a state fit for combination; and to all these is superadded the agency of the vital principle, the object and effect of which is continual alteration, destruction, and reproduction.

By supposing the establishment (or diversion) of a set of changes in the blood, we may possibly gain some insight into the cause of the powerful effects of some apparently insignificant medicines belonging to this division of Hæmatics. Neurotic medicines appear to act by their mere presence, contact, and excitation. This may not always be the case with Catalytics. Their power cannot in all cases be clearly accounted for by a simple and direct influence on the blood, the muscles, the nerves, or any of the tissues. It seems sometimes as if it were on the processes that their presence sets going, and on the products thus generated, that their influence and power depend.

It may be observed that this idea of action by contact cannot by any means be supposed to favour the very unreasonable theory of the efficacy of infinitesimal doses of drugs. For such medicines must of necessity be present in some amount, or they cannot act at all. Their operation cannot be like that of the putrefying yeast, or of the poisons of contagious fevers, each of which can reproduce itself out of the elements of the changing or fermenting body. For Antimony, Mercury, and Iodine could never make themselves out of blood, which does not contain them. Like the Emulsine in the production of Hydrocyanic acid out of the material of the bitter almond, they must be present in certain quantity, or they are quite inoperative. Even a tenth of a grain would generally be powerless, not to mention such irrational quantities as the thousandth, millionth, or even decillionth of a grain. (*Vide* p. 57.) Experience—better even than theories and mathematics—is entirely opposed to such chimerical fancies.

Having thus entered into a speculation concerning the probable action in the blood of Catalytic remedies, I must once more remark that this idea forms no part of the Proposition in which I have defined their mode of operation. In the present state of our information on the subject, we cannot certainly say more than that these remedies, by some blood-action, are able to antagonize and to annihilate certain disorders in the blood.

The resolution of a disease thus effected may, in a few instances, be partly explained by certain chemical considerations, as will be particularly shown in the case of Antiarthritics.

It remains for me now to add some remarks on the individual *modus operandi* of the substances included in each of the eight orders of Catalytic medicines.

ORD. I. ANTIPHLOGISTICS.

ANTIMONIALS. MERCURIALS. ALKALIES. SALINES.

The condition of the system called Inflammatory fever, indicates inflammation of an acute or sthenic type. Either of two causes may produce this. A local injury, in which the nerves of the part sympathize, may, by the reflection of this irritation through the nervous centres, affect the circulating system, and cause Fever. The existence in the blood of certain morbid poisons, as those of Gout or Rheumatism, may produce the same result in a more immediate way. This fever is high fever. That is, not only is the action of the heart excited, but the condition of the blood is invariably altered.

There is found in its composition an exaggeration of the healthy state, an increase in the natural amount of those elements on which nutrition and life depend. When it springs from a local injury, this state of blood commences in the capillary vessels of the part injured; from thence it spreads to the blood generally, if the wrong is extensive, and rapidly involving the whole vascular system, converts a temporary mischief into an established evil. The blood now contains an excess of Fibrine, causing it, on coagulation, to exhibit the "buffy coat." There are also found in this, according to Mulder, some peculiar hyperoxides of Proteine. The colourless corpuscles are in excess; and among the red corpuscles is observed a peculiar tendency to arrange themselves together in rows. This is doubtless in some way connected with the morbid process going on in the blood.

Those medicines which I have grouped together as Antiphlogistics, are enabled to counteract in a most direct way this state of things. They have the power, when introduced into the blood, of diminishing the amount of Fibrine in it. By so doing they remove from the heart a cause of irritation, and allow the pulse to subside; and they retard or prevent those effusions of plastic lymph from the capillary vessels, which are a great source of peril. (When these are already formed, they assist in their removal by absorption. For they render the blood poor, and on account of this the absorbents are impelled to the solution and imbibition of nutrient matter wherever it can be found.)

A double caution may be given as to the use of these remedies. They may be given in sthenic inflammation and in high fever, but not in low inflammation or low fever. In these asthenic forms, half the symptoms of inflammation are wanting, and half the symptoms of fever. We may have inflammation, so called, produced by the syphilitic or scrofulous poisons. We may have fever, so called, resulting from the poisons of Typhus or Scarlatina. The want of strength in the pulse, and the failure of power in the system, show us that we have not here the condition of blood above mentioned. In fact, in these low cases, the fibrine is diminished, instead of increased in amount; the well-known "buffy coat" is not formed on coagulation, and the blood is in a state which contra-indicates the employment of antiphlogistic agents. Any approach to a true hypersthenic condition will immediately constitute an exception to this rule, which is nevertheless of very great importance.

Given with proper precautions, these remedies are appropriate in all acute inflammations that commence locally, whether the ultimate cause be a wound, or some morbid irritation or change in a part or organ, as in Pleuritis, Cerebritis, Hepatitis, Orchitis, Peritonitis, etc. Also in acute inflammation from morbid poisons, as from Gout or Rheumatism. But here the Catalytic remedies which tend more directly to counteract these poisons, and thus to nip the mischief in the bud, must be the first considered.

The acute inflammation with which we have to deal may be a matter of the utmost moment. The inflammatory process—the chief seat of which, however it may first originate, is in the circulating blood—exerts a powerful influence over the nervous system, and may, by this influence, cause death. When fever is produced to any extent, there must be danger. We are enabled in two ways to control or to mitigate this state of things. We may produce an action on the nervous system, or we may direct our attention to the process in the blood.

Of Neurotic medicines, which we shall have to consider hereafter, there are some which may be made use of at the commencement of the attack, and others which are appropriate when the process is more advanced. Of the first kind is Antimony, considered in its Neurotic action. Employing it in large doses, we may produce a powerful effect upon the nerves which supply the heart, and thus by diminishing the impulse upon the inflamed parts, or on the vascular system generally, promote absorption and resolution. Blood-letting produces the same action, but in an inverse mode. Antimony diminishes the pressure on the vessels by weakening the force of the heart; Blood-letting weakens the force of the heart by diminishing the pressure on the vessels.

Such Neurotics as Opium are employed at a more advanced stage, when the inflammation cannot be suddenly put a stop to, and our object is to counteract the effects it has produced. Besides relieving the pain and nervous irritation which are so much to be dreaded, Opium may be employed to prevent a blood-medicine from passing out through the bowels. Antimony and bleeding are appropriate in sthenic cases. Opium should not generally be employed in these instances, nor should it be given in brain disorders, or in any case where there appears to be a determination of blood to the head.

Certain medicines of the class of Eliminatives, and certain Catalytic remedies belonging to the present order, are employed to counteract the inflammatory process in the blood.

Of the former, the most important are Purgatives and Diaphoretics. By diminishing the amount of the serum of the blood, they not only tend to check effusions, but act indirectly on the heart, in the same way as the medicines last spoken of; and they probably also promote the passage of morbid or of peccant materials out of the system through the glands. Acid and saline drinks may act as Diaphoretics, besides exerting each a peculiar influence in the fluids.

Becquerel and Rodier have shown that in acute inflammations the proportion of Fibrine in the blood is increased on the average to 5·8 in 1000 parts, nearly double the amount of health. By the recent inquiries of Richardson,* Thudichum, and Barker, it appears that the use of Antimonial salts, when persevered in, produces a watery condition of the blood, diminishing especially the amount of Fibrine. But this blood action, which directly counteracts the conditions of inflammation, is still more apparent in the case of Mercury. This has been loosely stated by a multitude of authors, but definitely shown by the chemical analyses of Dr. Wright.† From these we learn that the mercurial agent, by some inscrutable chemical power, of whose nature we know nothing, is able to

* See *Chemist*, vol. iii. p. 615.

† See *Christison's Dispensatory*, 1842, p. 507.

decompose the blood; by some destructive agency it deprives it of one-third of its fibrine, one-seventh of its albumen, one-sixth or more of its globules, and at the same time loads it with a fetid matter, the product of decomposition. Such power is possessed by few other medicines, and certainly exerted by none in the same degree as by Mercury. It is an agent of terrible activity, and we may well be cautious how we handle it.

Of this Catalytic order, Antimony and Mercury are those which tend most powerfully to check the general blood-process of inflammation. The former is used in urgent and acute cases to make a sudden and powerful impression, adding to its Hæmatic action a sedative effect on the heart and circulation. Mercury exerts no such immediate influence. Diminishing the Fibrine of the blood in a more marked manner than Antimony, and having other operations of a peculiar kind in this fluid, it powerfully promotes absorption and counteracts effusion, in all inflammations. The blood-action of these remedies, though not positively slow, is slow when compared to an action on nerve. Thus when Antimony is given in large doses, as is desirable in some highly sthenic and dangerous attacks, its blood-action is lost in its immediate Neurotic operation.

So that in Croup and Pneumonia, both rapid and fatal inflammations, Antimony is far preferable to Mercury. But in Pleurisy, where there is generally no immediate danger to be dreaded, but a subsequent effusion, Mercury is best, being in time to lessen or to prevent this result.

From the action of both on the blood, and one on the nerves, these are very lowering remedies. In the employment of Antimony in fevers and inflammations, the production of nausea generally indicates that it has taken sufficient effect; but it may sometimes be better to give such a dose as shall cause vomiting, especially when a violent counter-irritant action is to be desired. The increase in the quantity of saliva and slight soreness of the mouth, which result from its action, will show when the administration of a Mercurial has gone far enough. It is seldom advisable to cause copious salivation.

Alkalies dissolve the Fibrine of the blood, and appear by this to lessen its deposition, and retard its formation. Dr. G. Bird has found that those ingredients of the urine which are produced out of the destruction of the Proteine compounds of the body, are increased largely in amount by the administration of Alkalies. Thus, when given in large doses, they operate as Antiphlogistics. They have sometimes been employed with advantage in fevers of the acute or sthenic kind.

Exerting an influence over the inflammatory process considered *per se*, Alkalies and Mercurials are more particularly efficacious in some special varieties of inflammation, because in such cases they further counteract the morbid agency by which the process is excited and kept up.

Salines, too, diminish the fibrine of the blood, but do not decompose that fluid in so thorough a manner as the metallic Antiphlogistics. Administered for some time, they produce a condition of blood like that of Scorbutus, a disease in which the alkaline salts natural to the blood are increased in amount, as Becquerel, Andral, Gavarret, and Frémy concur in stating. Salts have the chemical power of preventing the coagulation of fibrine, and of dissolving it to some extent when coagulated.

By this they both hinder the nutrition of the tissues, cause wasting of the body, and favour the excretion of the albumino-fibrous element in various forms. The solid organic parts of the urine are increased by the use of salines. The action of salts on the blood has been remarked by Schultz, Löffler, Stevens, and Basham. Nitre especially, by this impoverishment of the blood, is found to reduce the action of the heart, and the rate of the pulse. Being a simple chemical action, the operation of salines as Antiphlogistics is more easily understood than that of Mercury and Antimony.

In the Typhoid and Eruptive fevers, when the blood is already sufficiently deteriorated, when we wish to produce an effect on the circulating system, but do not think it desirable to reduce the vital powers beyond a certain point, Salines, as Nitrate and Chlorate of Potash, supply us with a set of valuable and sufficiently mild Antiphlogistic agents. It seems that they not only exercise a solvent power over Fibrine, but also keep asunder the corpuscles which tend to adhere together in inflammatory blood. This operation on the corpuscles has been observed by Mr. Gulliver. Salines were long ago proposed by Mascagni in acute inflammations in general. Nitre, in large doses, has been used with considerable success, by Dr. Garrod and others, in acute Rheumatism.

Salts are excreted, and act on the skin, or the kidneys, or the bowels. They are not so potent as Alkalies; for salts pass out of the body as they went in; but Alkalies pass out into the secretions as salts, having first combined with acid in the system, so that they must leave behind them a certain excess of alkali in the blood, by which their action is continued for some time. (*Vide Alkalies; Prop. VIII.; Antimony, Mercury, and Sulphate of Magnesia, in Chap. IV.*)

ORD. II. ANTISYPHILITICS.

MERCURIALS. PREPARATIONS OF GOLD AND PLATINUM? IODIDE OF POTASSIUM. SARSAPARILLA?

These are medicines whose operation in the blood results in the counteraction or neutralization of the syphilitic poison.

Syphilis is evidently traceable to a special poison. This is recognised by the fact of its communication from one person to another. In the system of the infected person, if left alone and uncontrolled, it breeds and increases in quantity, works out all the mischief that it is capable of effecting, and may again be propagated to others, either by inoculation into the blood, or by an equally direct transmission to a tainted offspring.

In primary forms of Syphilis, as the chancre, and early eruptions,—as syphilitic Lichen, Roseola and Lepra,—also in syphilitic Iritis,—Mercury is the single and best remedy.

Its power is very widely admitted, both by English and Continental surgeons. It is often esteemed a specific. Among others, Mr. Hunt, in a treatise on Syphilitic eruptions, maintains that Syphilis has a tendency to go on without limit if left alone, but that Mercury in sufficient doses possesses the power of totally destroying the poison, and preventing its transmission. And he states that secondary symptoms have become more prevalent, and the aggregate of deaths from Syphilis has considerably increased, since the use of this remedy has been given up by many practitioners.

Mr. Carmichael was of opinion that Mercury was only applicable in those cases which exhibited the true Hunterian chancre, round, cup-like, and hard, followed by a leprous eruption. But it is more in accordance with common experience to say, that the only contra-indications to the use of Mercury in primary Syphilis are these,—a scrofulous or very debilitated state of the system; and a sloughing or irregular appearance of the primary sore.

It has been shown, under the head of Antiphlogistics, that Mercury has the power of producing a decomposition of the blood. But it is not simply by doing this that it can cure Syphilis. It is more probably in another way. Syphilis, with the eruptions, and ulcerations, and necroses, and the cachexy that results from its working, is obviously an agency which itself tends sooner or later to impoverish the blood, and it seems to me to be not unreasonable to suppose that Mercury, in its destructive action, may seize first on those parts of the blood which are most diseased, or most liable to putrefaction, that it may grapple thus immediately with the fermenting and multiplying virus of Syphilis, decompose it, as well as those materials of the blood on which it has commenced to feed, and eliminate both these and itself together by the glandular outlets of the frame. To cure the corrosion of the vital parts, the Mercury corrodes somewhat further and deeper, and sweeps all away. Its use, if this be so, may be compared to the wise plan of blowing up a number of houses to save a city on fire.

There is no doubt something peculiar in the blood-action of Mercury, which brings it into special relation with Syphilis. If given in excess it produces a form of rash, which stamps it as a distinctive blood-poison. Its resolvent action is shared by other remedies.

We may administer mercury in two forms. It may be given as Calomel or Blue Pill, with or without Opium, and continued until it affects the mouth. Or the Bichloride may be administered in minute doses, and may prove efficacious without producing salivation. It should be commenced as early as possible; and in most cases the action of Mercury in the blood, of whatever nature that action may be, will meet and neutralize the advance of the syphilitic virus, preventing its further manifestation in a secondary form. It is rarely necessary to push its action beyond the first symptom of salivation; for that will be evidence that the system is sufficiently saturated with it. Beneficial as it often proves when administered thus cautiously, yet if given in excess, or to individuals that are over-susceptible of its action, it is capable of proving a poison every whit as noxious as the Syphilis which it was intended to neutralize. The Mercurial cachexy is quite as deplorable, and quite as incurable, as the Syphilitic cachexy.

The Terchloride of Gold may be used in Syphilis in the same way as the Bichloride of Mercury; but it is much more seldom employed. There seems to be a strong medicinal as well as chemical similarity between these two metals and their compounds. Even the metallic Gold itself was used some time ago as an Antisyphilitic, apparently with success. In 1715, Dr. A. Pitcairn recommended finely-powdered Gold as even more efficacious than Mercury in the treatment of Syphilis. Its use has recently been condemned by Cazenave and Biett.

The Salts of Platinum have been recommended in Syphilis by Höfer; but in this country we have had no experience of their utility.

Mercury is the best remedy in primary forms of Syphilis, where the constitution is affected. But, to be of use, it should be given when the disorder is comparatively recent. In the later forms of the disease, called secondary and tertiary, the mischief is already done, the blood is depraved, and a new phase of morbid action has taken the place of the first. Here, Iodide of Potassium is the remedy; and Mercury, if ever prescribed, should be given most cautiously, or only in cases where its use was culpably omitted at the outset.

Thus, in Periostitis, ulceration of the mouth and throat,—or in any of the late rashes, as Rupia,—Iodide of Potassium should be given. Its efficacy in such cases was discovered by the late Dr. Williams. It may sometimes fail to effect a cure; a failure which is often due, as I have said, to the omission of Mercury in the treatment of the primary disease. It would seem as if it were a certain smouldering action of a part of the poison which has escaped the operation of Mercury, but has been modified by it, which is best capable of being met and controlled by Iodide of Potassium. It is worthy of remark, too, that the late affections, in which Mercury often does little or no good, are in many points to be compared to the disorders of the Scrofulous cachexy, where also, except in small doses, this remedy is contra-indicated, whereas in both classes of cases the preparations of Iodine are used with admirable effect.

In cases where the Iodide fails, I have found that a course of the Bichloride of Mercury, combined with Sarsaparilla or some bitter tonic, proves very beneficial.

But the action of the Iodide on a case of Periostitis, and the rapid absorption that follows its exhibition, are sometimes fully as remarkable as the influence of Mercury over the primary disorder, or in a case of Iritis.

Sarsaparilla is a very doubtful member of this order. It contains a soluble principle called Smilacine. It is thought by some to purify the blood, and also to have a kind of specific influence over it in old syphilitic cases. If it were so, we should have from the vegetable kingdom a distinct analogue to one of these mysterious mineral Catalytics. But it is so rarely given without being combined with some more powerful agent, that it is difficult to judge whether or not it may have any striking virtues of its own.

The Antisyphilitics, particularly the insoluble compounds of Mercury, are frequently employed as local applications to sores and eruptions. When these have a syphilitic origin, the mercurial doubtless combats the local manifestation in the same way that it can counteract the general action in the blood. In other cases the Mercury may pass into the blood of the part, and, by exerting in it its antiphlogistic operation, the result of which is to diminish its plasticity, may thus promote absorption. Mercurial ointment, if rubbed into the skin, becomes in part absorbed, and may thus produce salivation. Some prefer to introduce the remedy into the system by this external application, especially in cases where it is found to disagree, or to act in an uncertain manner, if taken into the stomach.

ORD. III. ANTISCROFULICS.

IODINE. BROMINE. CHLORINE. IODIDES. BROMIDES. CHLORIDES. POTASH.

Scrofula is a blood-disease. All its manifestations are explainable on such a supposition. It is transmissible from parent to child; and it holds good as a general rule that hereditary diseases are seated in the blood. It is unaffected by any of those medicines that act only on the nerves. It produces a deterioration of the blood.

Antiscrofulics are medicines which have the power of counteracting the poison of Scrofula in the blood. Common and pernicious as is this disease, there are not many Catalytic remedies which exert any marked control over it. It is a cachexy which influences and deteriorates, at one and the same time, the solid tissues, and the blood, which is the medium of their nutrition; and by introducing a remedy into the latter, we cannot always hope to affect the former. When a strumous condition is chronic, and has firmly established itself—when it has descended through many generations of the same family,—it is very intractable and difficult to cure. Palliative and indirect remedies, aimed rather at the consequences than at the source of the disorder, are often adopted with benefit. Tonics, Chalybeates, Cod-liver oil, and cold-bathing, are frequently of use in improving the condition of the system, when debilitated by the long continuance of strumous disorders. But the most important and direct remedies for Scrofula are to be found in Iodine and its compounds.

The compounds of Bromine and Chlorine resemble in their action those of Iodine. All have the power when taken in sufficient quantity, of diminishing the fibrine of the blood, and causing wasting of the tissues. This action is most apparent in the case of Iodine. But it is probably not simply as a resolvent that Iodine acts so beneficially. That it has some other more mysterious blood-action we know, by the train of symptoms called Iodism, which it is capable of producing, and which are peculiar to it. The most prominent of them are coryza, itching, watering of the eyes, a peculiar rash, fever, and great constitutional depression. Iodine works out of itself a peculiar operation in the blood.

It is not to be wondered at that in many cases of deeply rooted blood-disease, complicated perhaps with anæmia, structural change of organs, disordered assimilation, and various nervous symptoms, all remedies alike should prove useless. So that the experience of many practitioners, thus frequently disappointed in their hopes of a cure, has led them to question altogether the efficacy of Iodine in Scrofulous disorders. But it is generally allowed that it is more beneficial in such cases than any other medicine, and is the only remedy which is universally applicable in Scrofula.* If this be true, it follows that it must have a special power over this blood-disease.

Burnt sponge, and the ashes of a seaweed, the Fucus vesiculosus, both of which contain Iodine, have been used in Scrofula from very early times. But it was not until the present century that Iodine was discovered, and its efficacy in Scrofula, particularly in the cure of Goitre, pointed out by Dr. Coindet of Geneva. After this it came to be generally applied in all Scrofulous cases, and was especially recommended by M. Lugol in France, as a specific for such maladies.

When given for some time, Iodine has the effect of impoverishing the blood, like Mercury and many other Catalytics, diminishing in it the amount of fibrine. All remedies which do this favour absorption. This effect is obviously connected with the alteration in the blood, and there is no reason to suppose that any special stimulant action is exerted on the absorbent vessels. Those Catalytics which favour absorption

* "From what I have seen of the power of Iodine in Scrofula, I regard it as one of the grandest agents in the Pharmacopœia. And in this opinion I do not stand alone."—*Dr. Willshire.*

are not all useful in the same cases, but some are most useful in one disorder, some in another. Thus they must exert a special action over morbid poisons; an action which is altogether distinct from the influence over absorption, although by this latter they may be able to cause the disappearance of effused products, and of tumours produced in various ways.

In some rare cases Iodine has even been known to cause the absorption of healthy glands, as the mammæ and testicles.

Iodine and Iodide of Potassium, when successful, do not merely cause the disappearance of scrofulous tumours, but further meet and neutralize the poison which is working in the system, and effect a more or less permanent cure.* This could hardly be done by a remedy which had only the power of promoting absorption.

It seems that some systems are able to bear with impunity very large doses of Iodide of Potassium. I once met with a medical man who denied its power altogether, because he himself had frequently taken a scruple, and sometimes a drachm at a time without any effect.† Other men are readily affected by very small quantities, and quickly experience the symptoms of Iodism. It is probable that in the former case the medicine is very quickly eliminated by the kidneys; but that in the latter it remains in the system for some time.

It is easy to recognise such an action as that of Iodine in Scrofula, but it is almost impossible to invent a satisfactory explanation for it.

The Iodide of Iron is a most useful medicine for scrofulous children, who commonly suffer under Anæmia, as it combines a Chalybeate with an Antiscrofulic action.

* "Crescit indulgens sibi dirus hydrops,
Nec sitim pellit, *nisi causa morbi*
Fugerit venis, et aquosus albo
Corpore languor."—*Horace.*

† Very large doses are frequently prescribed by continental practitioners.

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Bromine and Chlorine resemble Iodine in their Antiscrofulic effects. It is said that Scrofula and Consumption are unknown among the workmen in bleaching factories, where Chlorine is being constantly inhaled. Thus it has been strongly recommended that diluted Chlorine should be inhaled by consumptive patients. It is probable that part of the efficacy of seaside air and sea voyages in scrofulous cases may be due to the free Chlorine which is given off in small quantities from the salt water of the ocean. The powers of Iodine and Bromine are shared by their compounds; and Chlorine is no exception to this rule. The bad consequences which follow the omission of common salt from the food, are sufficient to show that this substance has a beneficial action on the blood. Probably large doses of this article of diet would be found advantageous in Scrofulous disorders. The Chloride of Ammonium, as shown by the experiments of Dr. Lindsay, is a powerful resolvent agent. It has been found beneficial in Scrofulous disease of the liver by Dr. Budd.

Chloride of Barium has been much extolled as a remedy for Scrofula. It was introduced into practice by Dr. A. Crawford in 1789. (*On the Medicinal Properties of Muriated Baryta.*) It has since been administered by Hufeland, Priondi, and Baudelocque. It may be given in a dose increased gradually from five grains to a drachm or more. It is now nearly out of use, though Mr. Phillips is of opinion that "it has a better claim to a place in the Materia Medica than medicines which have a firmer hold." (*On Scrofula*, p. 281.) Supposing its efficacy granted, it is a question whether it is then to be attributed to the Barium or to the Chlorine. I confess that I incline to the latter. After all that has been said about the efficacy of Barium as an Antiscrofulic, I cannot find that a decided benefit has followed the use of any of its compounds except the Chloride.

Potash, free or carbonated, is another remedy of considerable importance in Scrofulous diseases. It is possibly one of those Catalytics which exert a simple chemical influence. It may act by holding in solution fibrinous and fatty matters, and preventing their abnormal deposit in a crude form in the shape of tubercular matter. It may also be found useful in cases of Syphilis, when aggravated by a previously existing strumous tendency, and where a course of Mercury cannot be safely prescribed.

Small doses of Mercury, as an alterative, are often efficacious in scrofulous constitutions. They appear to act simply by stimulating the torpid liver to a performance of its proper function.* (*Vide* page 177.)

Potash has been used as a prophylactic against Consumption. The efficacy of Cod Oil in this disease has been explained by some as depending on the Iodine which it contains in small quantities. I do not consider this explanation to be the correct one. (*v. Cod Oil, in Chap. IV.*)

ORD. IV. ANTIARTHRITICS.

COLCHICUM. NITRIC ACID. NITRO-HYDROCHLORIC ACID. CITRIC ACID, AND LEMON-JUICE? MERCURIALS?

In this order are included some blood-medicines which exert a direct influence over certain disorders which depend each on some fault in the complicated process of assimilation and nutrition.

In each of the disorders of the Arthritic group there is a morbid material present in the blood which the system en-

* Dr. Mead, in 1751, recommended the employment in Scrofula of burnt sponge, and a pill containing "sublimated Mercury" and precipitated Sulphuret of Antimony. Plummer's pill is often prescribed in these cases at the present day. But neither Mercury nor Antimony are true Antiscrofulics. "In the sense of a remedial agent, capable alone, and under ordinary circumstances, of removing Scrofula from the constitution, Mercury is not, I believe, entitled to any confidence."—*Phillips on Scrofula*, p. 273.

deavours, with more or less energy, to cast out into the secretions. The chief of these diseases are Diabetes; Oxaluria; Lithic deposit in the urine; and the true Arthritic disorders; *i. e.*, Gout and Rheumatism. Most of those blood-diseases which cannot be clearly traced to the introduction of a poison from without may be arranged under this head, and appear to be curable by the same set of remedial agents.

The medicines enumerated above as Antiarthritic agents are recognised on general grounds as capable of acting in the blood. Colchicum has a power of impoverishing this fluid, which may possibly be connected with its purgative action. But it has further a power of diminishing the amount of Uric acid which is present there in some morbid conditions. This does not appear to be an action of elimination. Nitric and Nitro-hydrochloric acid are oxidizing agents. Used in health, they increase the waste of the plastic elements. In disease, they may direct their energy towards various unnatural products. Citric and other vegetable acids have a mysterious power of correcting a putrid blood-crasis, such as exists in Scorbutus, and appear chemically to divert the process of oxidation in fevers. And Mercury, a doubtful Antiarthritic, has been already spoken of as a potent blood-medicine.

Concluding, then, for the present that these are blood-medicines, we revert to the disorders which they tend to control, in their special capacity, as Antiarthritics.

There are certain processes always going on in the blood whose continuance in the right direction is essential to health. When one of these processes is disturbed, it does not generally cease, but it goes on then in a wrong direction.

The natural processes result, on the other hand, in the preparation of fit and proper nutriment out of the materials of the digested food, for the growth and support of the several tissues and functions; and, on the other hand, in the gradual change and conveyance out of the body of the products of the waste of those tissues. But when any process goes on in a wrong direction, it results in the formation of various products different from those which are required, and which the kidneys and other glands are at length called upon to excrete from the system. The result is that the general health is more or less seriously impaired.

There is also another way in which these diseases are not unfrequently caused. A natural process may stop at a certain point, and go no further. The material formed at that stage remains as it is. It is not wanted; it is morbid; and it also is excreted from the body. It is possible that these errors in the assimilative processes may sometimes arise in the first instance from a deficiency in the blood of some substance whose influence was necessary to the proper conduct or control of the natural series of changes. Some of these conducting materials may be formed by the liver; for it is found that these disorders are very commonly connected with an impairment of the function of that organ. Thus Mercury, which restores the secretion of the liver, may be for this reason useful in Arthritic disorders; as also Quinine, which has already been shown to have a peculiar relation to liver diseases.

But these disorders, however they may first originate, consist in an active morbid process of one kind or another; and the surest way of counteracting this process, or of diverting it into a right direction, is by the employment of one of the Catalytic medicines contained in this order. Some stages of these diseases are attended with a want in the blood of some of its ordinary constituents; which condition may be relieved by the supply of a Restorative remedy.

Thus in this group of disorders three kinds of medicines may be employed,—Eliminatives, Catalytics, Restoratives,—which tend in various ways to improve the condition of the blood.

Acids and Alkalies are sometimes needed, and act on the Restorative principle. The true Antiarthritics are those medicines which are employed on the Catalytic plan, to meet and neutralize the morbid material or process in the blood. And sometimes Eliminatives are made use of, which seem, by acting on the secretions of the skin, kidneys, or bowels, to be able to rid the blood of an unnatural product. Thus Guaiacum and Salines are employed in Rheumatism, and Purgatives in Gout.

These two joint affections are most characteristically under the influence of Catalytic remedies. Diabetes and Lithiasis are more under the control of Restoratives than the others.

The medicines composing this fourth order of Catalytics have been already enumerated.

That Colchicum tends in some way to neutralize in the blood the poison of Gout, and to a less degree that of Rheumatism also, is generally admitted, although various theories have been adopted to explain this action. (*v. Chap. IV. Art. Colchicum.*)

In Oxaluria, the employment of Nitric acid as a remedy was first recommended by Dr. Prout. Dr. Golding Bird advised the substitution of Nitro-hydrochloric acid, which has proved to be a most valuable remedy, not only in this disorder, but also in some cases of lithic deposit. The Oxalate of Lime rarely occurs alone in the urine; there is generally along with it some Urate of Ammonia. The causes of the two deposits appear to be in some way connected. So also are the remedies similar. Dr. G. Bird has found Colchicum to be of signal service in cases of lithic deposit in the urine; and has proved the same medicine to be efficacious in Oxaluria.

I will now attempt to show how the action of these medicines may admit, on certain grounds, of a chemical explanation. There are very few Catalytic actions in which such an explanation can be attempted, but a degree of plausibility appears to attach to the idea in this case, though it cannot of course be considered to be susceptible of more than a demonstration of probability.

I have already said that in all the disorders now under consideration there are certain morbid constituents in the blood which have been recognised by chemical tests. In Diabetes there is an excess of grape-sugar (Glucose) formed in the blood, and excreted from it in the urine. In Rheumatism we have a painful joint affection, attended with a great development of acid in the system; and this acid, which we have many reasons for supposing to be lactic acid, is occasionally excreted by the skin. In Gout we meet with another Arthritic affection, in which there is urate of soda in the blood, and an excess of uric acid and urea in the urine. This urate of soda may be discovered in the blood of gouty subjects by a simple test invented by Dr. Garrod, who maintains that the presence of this morbid product in the one, and its absence in the other disease, is the only constant point of difference between Gout and Rheumatism.* A simple excess of uric acid in the secretion of urine constitutes Lithiasis. There is an obvious but ill-understood connexion between Gout and the last disorder, and, indeed, between all those of which we are treating. In Oxaluria we have an abnormal formation of oxalic acid in the blood, which is excreted in combination with lime, for which base it has a great affinity. In Oxalic urine there is generally an excess of urea, as I have found in many cases.

Now, it seems to me that all these disorders are capable

* A few drops of strong acetic acid being added to some clear serum in a watch-glass, and a thread immersed in it, microscopic crystals of Uric acid will form on this thread after some hours. This presence of Uric acid in the blood is regarded as the test for gout. But, as it has been found by Cloetta in the lungs of healthy herbivora, and by Scherer in the spleen of man, it seems just possible that it may exist in small amount in human blood without giving rise to abnormal phenomena.

of being explained by reference to the series of changes in the blood which are associated with the respiratory process. (*Vide Liebig's Anim. Chem.*, part i. p. 133; *Dr. B. Jones' Anim. Chem.*, pp. 20, 118.)

It is the general opinion of modern chemists, that before the starch of the food can be applied to the maintenance of the animal heat, for which office it is chiefly intended, it passes through a series of chemical changes. First, assuming two equivalents of water, it becomes glucose; next, this changes into lactic acid, which is isomeric with it; and this again combines with twelve atoms of oxygen, to form carbonic acid and water. This last change is a process of combustion, and thus produces heat. The oxygen needed for it is absorbed from the air by the pulmonary mucous membrane, and the carbonic acid formed passes out of the blood at the same surface.*

Liebig was the first to point out the connexion between these changes and the phenomena of Diabetes. It is clear that if the process were to stop at the formation of Glucose, or grape-sugar, the condition of blood that exists in Diabetes would result. This sugar cannot be put to any use, and is excreted as fast as formed. There is an excess of urea in the whole quantity of urine passed in the day; probably because the nitrogeneous food and tissues are undergoing combustion instead of the starch. Before becoming Glucose, starch undergoes a transitional change into Dextrine, a gummy insipid substance which has the same composition as itself. It seems that the process may even stop as early as this, and that by this stoppage another analogous disease may be produced, *i. e.*,

* Mialhe (*op. cit.* p. 67) adopts a somewhat different view, considering that the Glucose as soon as it comes in contact with alkaline carbonates in the blood, changes into Glycosic acid, and this next into Glycic, Ulmic and Formic acids. But these have not been discovered in the blood or secretions, where Lactic acid has been found.

Diabetes insipidus. The common Diabetes is called D. mellitus. (*Vide Jones' Anim. Chem.*, p. 120; *Mialhe, op. cit.* p. 69.)

If it were clearly proved that the acid of Rheumatic fever is lactic acid, then this affection might evidently be produced by a stoppage of the process at the next stage. Lactic acid has been formed; but, for some reason unknown, it is not oxidized into carbonic acid. Urea and uric acid are in excess in the urine, from the cause alleged above.

But suppose some of the sugar to be oxidized prematurely, without passing first into lactic acid. By this oxalic acid would be produced, and the phenomena of Oxaluria accounted for.*

The correctness of the above explanation of Diabetes may now be considered as established. But these similar theories of other disorders are only alleged as possible, and for the purpose of showing that, should they be true, the action of some useful remedies might be elucidated. It is not at all unlikely that the accuracy of such ideas may be verified by fresh discoveries at no distant time. But let us continue.

In Gout and Lithiasis there is an excess in the system of nitrogenous matter, and thus a tendency to an extra formation of urea. These conditions are often brought on, and always aggravated, by over-indulgence in animal food. Now, if we may suppose that some of the lactic acid, instead of oxidizing directly into carbonic acid, oxidizes in combination with this urea which is in excess, then uric acid and water might result; as is shown below. The uric acid accumulates in the blood, or passes into the urine in excessive quantity.

Should this be the case, the great affinity existing between the course and symptoms of Gout and Rheumatism would be easily explained, there being in both disorders an impediment

* Some, as Dr. Rees, consider that it is Lithic acid, and not sugar, which undergoes the oxidation by which Oxalic acid is produced. But it is certain that Diabetes and Oxaluria are frequently concurrent.

to the proper oxidation of lactic into carbonic acid. These things may be illustrated by a diagram, showing the results which are supposed to take place when the natural process is arrested at, or diverted from, any of its stages:—

Starch.

+ 2 aq =

Grape Sugar..(Diabetes.)

+ O =

= Oxalic acid. (*Oxaluria.*)

Lactic acid..(Rheumatism.)

+ 2 Urea + O_6 =

+ O = Uric acid + 10 aq. (*Gout and Lithiasis.**)

Carbonic acid.

Thus, at each of the two transitional stages, we might have one diseased condition produced by an arrest of the process, and another by its deviation. These deviations and stoppages may result from a failure of some natural principle which is gifted with the control and direction of the series of transfor-

*Mialhe (p. 28) considers Urea to be the product of a higher oxidation than Uric Acid. He states that it is formed at the expense of the latter in the system of persons of active habits. But animal diet and sedentary habits do not invariably produce lithic urine or gout. The causes of Lithiasis and Gout are similar. In the former the Uric acid is discharged freely by the kidneys. In the latter there is some impediment to this; the acid remains in the blood combined with soda, or is discharged spasmodically in the neighbourhood of the smaller joints. The quantity of the acid increases in the blood, and diminishes in the urine, before the paroxysm of Gout. (Lehmann.)

mations; or they may simply be traceable to a want of vital energy or nervous force.

The same ideas may be more distinctly expressed by means of chemical equations.

Natural Process.

$$C_{12}\,H_{10}\,O_{10}+2\,HO = C_{12}\,H_{12}\,O_{12}.$$
$$= 2\,(C_6\,H_5\,O_5,\,HO.)$$
$$C_6\,H_6\,O_6+O_{12} = 6\,CO_2+6\,HO.$$

*Oxaluria.**

$$C_{12}\,H_{12}\,O_{12}+O_{18} = 6\,C_2\,O_3+12\,HO.$$

Gout and Lithiasis.

$$\text{Lactic acid} + 2\ \text{Urea} + O_6 = \text{Uric acid} + 10\ HO.$$

The last equation may be thus proved at length:—

$$\begin{array}{ccc} C_6\,H_6\,O_6 & & C_{10}\,H_4\,O_6\,N_4 \\ C_4\,H_8\,O_4\,N_4 & & \\ O_6 & & H_{10}\,O_{10} \\ \hline C_{10}H_{14}O_{16}N_4 & = & C_{10}H_{14}O_{16}N_4 \end{array}$$

It is next to be inquired how far the theoretical explanation of these diseases which has been thus sketched out can be applicable to the matter in which we are more immediately interested, viz., the action of the Catalytic remedies used to cure them.

For the radical cure of Diabetes there is no known remedy; though some relief may be afforded by a system of dieting. (*v. Aliments.*) It is supposed that what we have to do is to convert diabetic sugar, *i. e.*, Glucose, into lactic acid. This acid probably exists in the gastric juice. And some such substance as the decomposing Caseine in sour milk,

* Dr. O. Rees considers Oxaluria to be merely an accompaniment of Lithiasis. He relies mainly on the fact that the two deposits very frequently occur in conjunction, and that Oxalates may be produced by the mere agency of heat on lithic urine.—I may take the opportunity of stating here that since the first publication of this Essay, the above theory of the causation of Rheumatism has been adopted by more than one writer without acknowledgment.

which is capable of effecting this change out of the body, would be most likely to avail us, if we could contrive to introduce it into the blood. In an Essay on the Nature and Treatment of Diabetes, read before the Medical Society of London, I ventured to recommend that fresh milk should be freely consumed as an article of diet in this disorder—as it does not seem to be proved that its milk-sugar is liable to conversion into Glucose, or excretion in the urine—and, at the same time, that *milk just turned sour* should be administered in smaller quantities as a therapeutic agent. This recommendation has since been adopted with much success in several cases.

Yeast has been given, as a ferment likely to forward the development of grape-sugar. But there are two important objections to it. It tends to transform the sugar into Alcohol instead of Lactic acid;* and it operates only in the stomach, whereas it is in the blood that we desire the action of a ferment. Rennet has been recommended, with more plausibility. It has been tried and found beneficial by Dr. Gray of Glasgow. Being a material of rather variable nature, it is uncertain in its remedial action. Further, Berzelius and Mialhe have thrown grave doubts on the fact assumed by Liebig, that Rennet (*i. e.*, Pepsine) coagulates milk by producing lactic acid. Milk is more probably turned sour by some decomposing Caseine in the milk itself. On which ground I have recommended sour milk as a remedy in Diabetes.

In decided opposition to such recommendations, and on a principle which I believe to be altogether erroneous, some other remedies have been given in Diabetes with the intention of retarding, instead of forwarding, the fermentation or development of Glucose. Alum, Vegetable astringents, Caustic alkalies, and some mineral substances, have been proposed for this purpose. Bouchardat states that he has made trial of all of them, but without any benefit.

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* Baudrimont produced symptoms of intoxication by administering Beer yeast to a diabetic child. (*Journ. de Chimie Med.*, Mar. 1856.)

Oxidizing agents have been advised by some, as Nitro-hydrochloric acid, or the Permanganate of Potash used by Mr. Sampson. It is true that when the access of oxygen to the lungs is hindered from any cause, as in aged persons, or patients suffering from impeded respiration, a kind of diabetes is apt to result; at least, Reynoso and others have found that in such cases sugar accumulates in the blood, and is excreted in the urine. But whatever may be the physiological interpretation of this fact, it does not follow that we should be able to cure Diabetes by oxidizing medicines, for the development of grape-sugar into Lactic acid requires no oxygen.

Mialhe and others are of opinion that Diabetes is mainly due to a deficiency of alkali in the blood. They therefore recommend the administration of alkalies on the restorative principle. It is supposed that this alkali encourages the development of lactic acid in the system by combining with it as soon as it is formed. Alkalies have been given in Diabetes with variable results, and rather doubtful success.

Diaphoretics have hardly been tried so much as they deserve. I believe they may prove of signal service in this disorder. The secretion of sweat always contains Lactic acid, as ascertained by Berzelius, Anselmino, and Favre. And if we fearlessly urge this secretion by producing copious and repeated diaphoresis, we may perhaps stimulate the natural development of lactic acid in the system at large.

In Oxaluria, the best treatment consists in a course of Nitro-hydrochloric acid. This remedy is prepared by adding one part of Nitric to two of Hydrochloric acid; and is diluted considerably with water when prescribed. The Nitric acid causes the oxidation of some of the Hydrogen of the other acid, and thus sets free Chlorine gas. This is stated by Mr. Brande to go on until the liquid is saturated with this gas. The result of the presence of Chlorine is, that from the affinity of this gas for Hydrogen, by which, under certain circumstances, it is enabled to set free the Oxygen of water, this compound acid becomes the most powerful oxidizing agent known. This acid has been lately used as a remedy for Gout and Rheumatism, in spite of the acid state of the fluids in those cases; and I believe it to be a very valuable medicine in both of these disorders.* A simple mineral acid would do

* I have already observed, but without any way committing myself to the view, that Dr. Owen Rees considers the Oxalic diathesis to be merely a modification of the Uric. (*On Calculous Diseases*, 1856.)

harm in both instances. The Nitro-hydrochloric acid must operate in some special way.

It is probable that its action may depend upon its oxidizing power.

In Oxaluria it might cause the oxalic acid to be oxidized into carbonic acid, and thus restore health. Thus:

$$C_2\,O_3 + O = 2\,CO_2.$$

In Rheumatic fever, where we have supposed that lactic acid is formed as it should be, but then stops short, and proceeds no further, the oxidizing agent may convert this into carbonic acid.

In Gout and Lithiasis, where there seems to be an excess of nitrogen in the system, and thus more oxygen is needed to restore the equilibrium, I have supposed that lactic acid and urea are changed together into uric acid. If we adopt this hypothesis, it will be evident that under the above treatment this uric acid may be oxidized back into urea and carbonic acid, and the balance of health restored. Thus:

$$\text{Uric acid} + 6\,O + 4\,HO = 2\,\text{Urea} + 6\,CO_2,$$

which may thus be proved:

$$\begin{array}{cccccccccc}
C_{10} & H_4 & N_4 & O_6 & & & & & \\
 & & & O_6 & & C_4 & H_8 & N_4 & O_4 \\
 & H_4 & & O_4 & & C_6 & & & O_{12} \\
\hline
C_{10} & H_8 & N_4 & O_{16} & = & C_{10} & H_8 & N_4 & O_{16}
\end{array}$$

Such may be the action of Nitro-hydrochloric acid. It exerts a true Catalytic or counteractive influence.

But we have to explain the agency of another class of very different, and apparently opposite remedies. Alkalies are employed with benefit both in Rheumatism and in Gout; particularly in the former disease. Now I conceive these to act, in Rheumatism at least, simply on the Restorative principle; supposing lactic acid to exist in excess in Rheumatic blood. This by itself may have no more tendency to oxidize into carbonic acid than so much vegetable acid would have. In ordinary cases a free vegetable acid passes out into the urine without undergoing any change in the system. But it has been proved by Wöhler that the same vegetable acid becomes oxidized when given in combination with an alkali. So that if we introduce into Rheumatic blood a free alkali, a lactate of potash or of soda will be formed; this may then be enabled to oxidize into a carbonate, and the natural process be completed. Such appears to be the rationale of the action of alkalies. They have been recommended in Diabetes. By disposing of the lactic acid as soon as it is formed, it is thought that in some cases they may favour its development out of grape-sugar. They would be inefficacious in Oxaluria because the oxalic acid has so great an affinity for lime, that it could not be separated from this combination by an alkali.

Dr. Rees and others have found Lemon-juice of great use in the treatment of acute Rheumatism. It contains Citric acid, and some Citrate of Potash: the latter being in too small amount to explain the action of the remedy. I have already shown how it seems possible that the vegetable acids may act as refrigerants in simple fever; how they may then supply the place of the natural lactic acid in the blood, and become oxidized instead of the Proteinaceous compounds. (*v. Acids.*) But Rheumatic fever is a very different case, for there is here apparently an excess of lactic acid, and an arrest of its oxidation. In considering, however, the formula for Citric acid, we perceive that not only does it contain proportionally more Oxygen than Proteine, as was proved in the former instance, but more than lactic acid contains. It is

$$C_{12} H_5 O_{11} \times 3\ HO.$$

Thus it is possible that it may act as a carrier of oxygen to the lactic acid, and so help it on towards its transformation into carbonic acid. It appears to be decomposed in the system, for Dr. Rees has never known it in these cases to increase the acidity of the urine. The matter is obscure; but we can discern enough of it to convince us of the possibility of different medicines acting in divers ways so as to produce very similar results.

Lemon-juice contains some *Oil of Lemons*, which Dr. Cogswell considers to be the active agent. But it appears that boiled Lemon-juice, which contains none of this, is equally useful, as indeed is Citric acid alone. Dr. Fuller has found Lemon-juice far less efficacious than alkalies in the treatment of rheumatic disorders.

Colchicum has apparently some power in the diversion or control of these morbid processes, which we can only indicate, but cannot further comprehend. It is generally best to give it so that it shall neither produce purging, nor any great degree of general depression. (*v.* Colchicum, in Chap. IV.)

Mercurials, which act on the blood, and promote the secretion of the liver, are found to be of considerable use in the treatment of all of these diseases, but more especially in Gout. Mercury may destroy the morbid product whose presence constitutes Gout, in the same manner as I have supposed it is able to destroy the virus of Syphilis. But it is not clear that it is a true antiarthritic agent. Being a powerful eliminative, it may simply get rid of the products in question by means of the secretions of the bowels and other glands. Or it may act by virtue of its power in eliminating and producing Bile.* And it is very probable that some constituent of Bile, re-absorbed into the blood, may be able to exert a beneficial influence on the conduct of such processes as those which we have just now considered.

Quinine and Tonics have been strongly recommended by Dr. Todd in Gout; and they seem to be signally efficacious, both in this and in the other Arthritic disorders. This is a very interesting fact. If there should be any truth in an idea which I have explained at length in the article on Tonics (*vide* p. 175,) it would seem that these Tonics may be of use by supplying in the blood the place of one of the wanting elements of Bile. For in all arthritic disorders there is more or less of hepatic derangement.

There seem then to be several possible explanations of the cure of these Arthritic diseases. There are various different modes of operation by which a similar beneficial result may be produced by the employment of Nitro-hydrochloric acid, free Alkalies, Lemon-juice, Colchicum, Mercury, or Quinine.

If it should be proved, which is not unlikely, that the chemical theory propounded above for the purpose of accounting for the production of these disorders in the blood is in every respect a correct view of the case, the explanation put forth there of the action of the various remedies used in such diseases

*Nitro-hydrochloric acid is supposed by some to act also as an Eliminator of Bile. It is said to increase the amount of bile in the fæces. But I do not think that this is proved.

would acquire an additional probability. But at present it would be safe to regard this chemical explanation as in great part hypothetical, because depending upon a number of things which, although likely, are not altogether proved as yet.

All that we can affirm with certainty is that a number of blood-medicines are applied with advantage to the treatment of these kindred disorders, tending to counteract the morbid conditions by which they are severally produced. These Antiarthritics must operate, then, on the Catalytic principle.

A number of varieties and masked forms of these disorders are grouped together under the general title of Dyspepsia. The depraved condition of the blood which tends to the production of arthritic symptoms may, when controlled and disturbed by various causes, simply manifest itself by causing acidity of the stomach, flatulence, impairment of digestive power, and general lassitude. Different Antiarthritic remedies are applicable in different cases. Colchicum or Nitro-hydrochloric acid are serviceable when this condition of the system is of long standing. Small doses of Mercury are often efficacious. Tonics, and a Purgative occasionally, may be recommended in milder forms of the disorder.

ORD. V. ANTISCORBUTICS.

CITRIC ACID. LEMON-JUICE. OTHER VEGETABLE ACIDS. FRESH VEGETABLES. ACETIC ACID. LACTIC ACID.

These are remedies which are useful in the counteraction of Scurvy and Purpura. In these disorders there is a thin and poor condition of the blood, together with a deficiency in the amount of albumen, fibrine, and blood corpuscles, but a surplusage of alkaline salts; a tendency to hemorrhages and ulcerations, consequent on this condition of the blood; and great general depression and debility.

There is no doubt that these changes in the blood are due to a certain morbid action. After a careful consideration of all the facts connected with a visitation of this disease in Scotland, Dr. Christison arrived at the conclusion that it could only be explained by supposing the existence of an "epidemic constitution." It is certain, however, that there are some kinds of food which are likely to prevent the occurrence of this morbid action, or able to control it when it has been set up. It is well known that the worst forms of Scurvy occur among sailors in long voyages, who have been deprived for some time of fresh vegetable food; and it is often observed that those who are thus afflicted on land have been subjected to the same deprivation. But it does not follow as a matter of course that all those so deprived become the victims of Scurvy. Nor does the converse hold good, *i. e.* that those who sicken with Scurvy have invariably suffered from this particular deprivation; for very aggravated cases may occur in persons who have always lived on an ordinary mixed diet. And in an epidemic in the Perth prison, Drs. Christison and Maclagan traced the disorder to the absence of animal flesh and milk from the diet, which was exclusively "saccharo-farinaceous." (*Monthly Journal of Medicine*, July, 1847.)

On putting these facts together, I think we are driven to the conclusion that men of a particular constitution, or in certain seasons, are more disposed to Scurvy than others; and that when such systems are deprived of some articles of diet which are able to prevent or to neutralize the working of the disease in them, the latent morbid action is allowed to commence. Fresh vegetables, especially, are to be considered as materials which hinder the development of Scurvy in cases in which there is already a tendency to it.

Great value must be assigned to Potatoes, as a prophylactic element of diet. They contain free Citric acid, as appears from the several analyses of Vauquelin, Baup, and Michaelis. (*Pereira on Food and Diet*, pp. 373–4.) And as agents in the treatment of Scurvy, Potatoes stand second only to Citric acid, and materials which, like Lemon-juice, contain this acid in large quantity.

The vegetable and other acids enumerated above as Antiscorbutics, have all an action in the blood which is almost special to disorders of this type. In some mysterious manner they purify it, and restore it to its healthy constitution. Under their use the amount of fibrine and blood-corpuscles is raised to the normal standard. And the increased amount of alkaline salts (observed by Frémy, Andral, and Gavarret,) which, however they come to be so increased, may be regarded as the only recognisable *materies morbi*, inasmuch as these salts exert a direct destructive influence on the fibrine and corpuscles,—is diminished in equal proportion.

Of all substances of which trial has been made in the treatment of Scurvy, whether prophylactic or curative, Lemon-juice or Lime-juice has been by far the most extensively used, has confessedly proved of signal service, and is much the most popular. It is therefore generally employed on board ships. It contains Citric acid in a free state, and a small quantity of Potash, chiefly combined with this acid. The food of sailors afflicted with Scurvy consists mainly of salted beef and sea-biscuit. Both contain salts of Potash; neither contain Citric acid. So, from this consideration alone, it would seem that the free acid must be the remedial agent. But this conclusion is strengthened very materially when it is found that Citric acid, given in the pure state, is a most admirable antiscorbutic. (*See below.*) Vegetables in their fresh state generally contain a small quantity of this or some other acid; and fresh vegetable food, as has just been stated, is usually the best prophylactic against Scurvy and Purpuric diseases.

Dr. A. B. Garrod is of opinion that Scurvy is attributable to a deficiency in the system of the natural amount of salts of Potash; he therefore treats it with salts of Potash, and, as he says, with success.

(*Monthly Journal of Medicine*, January, 1848.) The salts of Potash, if used on such grounds, would obviously act as restorative agents, and supply to the blood a material in which it is deficient. Dr. Garrod concludes from analysis that the antiscorbutic articles of diet are distinguished by containing an abundance of the salts of Potash, but that the reverse is the case with the materials which form the staple food of those who are most liable to Scurvy.

He gives the following as the amounts of potash obtained from one ounce of each of the articles of diet named:—

Wheaten bread - - -	·259 grains.
Oatmeal - - - -	·054 "
Salted beef - - - -	·572 "
Boiled potatoes - - -	·529 "
Lemon-juice - - -	·846 "

Thus it appears that lemon-juice and potatoes contain more Potash than wheaten bread, and much more than oatmeal. But they do not so much excel salt beef in this particular, and that is one of the chief articles of diet among sailors.

Dr. Garrod recommends the use of Nitrate of Potash. This proposition is certainly not new. The employment of Nitre was advised by Mr. Patterson, in a treatise on Scurvy, published some fifty years ago. It is true that he combined this remedy with Vinegar. Neither is it a new theory that Scurvy is connected with a deficiency of Potash in the blood. A similar idea was broached by Dr. Stevens in 1832, and afterwards taken up by Dr. Aldridge, who erroneously stated that there was a deficiency of Lime and saline matters in the serum in this disorder.

I object to the theory and practice of Dr. Garrod on several grounds. I think it may be proved that Lemon-juice owes its efficacy to Citric acid; that Citric acid is an Antiscorbutic when given alone; that the salts of Potash are not Antiscorbutic when given alone; and that neither in the blood nor in the food of scorbutic patients is there a marked deficiency of Potash. On theoretical grounds the theory alluded to is untenable; when brought to the test of practice, it signally fails.

The propositions just laid down may be supported by a few brief statements. *Lemon-juice owes its efficacy to Citric Acid.* According to the analysis of Proust, it contains Citric acid, 1·77; Malic acid, gum, and bitter extractive, 0·72; water, 97·51; in 100 parts. According to Dr. Garrod it contains only ·17 per cent., or about one part in 600, of Potash. There is no doubt that Proust much underrated the proportion of Citric acid. Dr. Bence Jones finds that an ounce of Lemon-juice contains from twenty-seven to twenty-eight grains of anhydrous Citric acid, and about three-quarters of a grain of Potash, equivalent to two grains of Citrate of Potash. He has conducted a number of experiments on the juice, which show that its action on the animal system is in all respects identical with that of free Citric acid, and entirely distinct from that of a neutral Potash salt. "For all practical purposes," concludes Dr. B. Jones, "we may regard Lemon-juice as a solution of free Citric acid. The analyses referred to were performed by Dr. Hoffman. (*Medical Times*, October 21, 1854.) Lemon-juice from which the free acid has been removed by Lime, is of no use in Scurvy at all.

Citric acid, given alone, is an admirable Antiscorbutic. Dr. Trotter long ago stated that he had experienced the powers of this acid against Scurvy to be equal to any effect he had ever observed from the recent fruit in its most perfect state. (*Medical and Physical Journal*, vol. iv. p. 154.) And of the juice of the fruit he records that it was found "a most infallible remedy" both in the cure and prevention of Scurvy. The advantage attending the use of this acid in sea-voyages is recorded by Sir Gilbert Blane and by Dr. Bryson. (See below.) Dr. M'William, who has had a large experience of its use, assures me that he has found the simple Citric acid an admirable remedy in sea-scurvy. Dr. Ritchie gives sometimes Citric acid, sometimes Lemon-juice, and finds them equally serviceable. (*Monthly Journal*, August, 1847.) And in an epidemic of Scurvy in Cumberland, Dr. Lonsdale found that in patients put on a full supply of a Citric acid mixture, the average duration of the disorder was not more than twenty-five days. So that the positive experience of these and of other physicians is in direct confirmation of the probability already established, that Lemon-juice owes its remedial efficacy to this acid.

The salts of Potash are not Antiscorbutic when given alone. To the cases brought forward by Dr. Garrod and a few others, it may be objected that fresh vegetables were always ordered as an addition to the diet, at the same time that Nitre was given as a medicine. I ascribe the few cures recorded to the use of these fresh vegetables. Was any patient ever cured by the salt of Potash without this accompanying alteration in diet? I think not. The fairest opportunity of making such a trial is in the case of sailors at sea, who cannot obtain green vegetables. Such a trial has accordingly been made, and the details are reported by Dr. Bryson. (*Med. Times*, March 23, 1850.) Instructions were given some years ago to the surgeons of several convict ships, that if Scurvy broke out during the voyage, they were to try the relative effects of Lime-juice, Nitrate of Potash, and Citric acid, choosing similar cases for experiment, and putting the patients under the same circumstances of diet and exercise. The trial was made in ten ships; the disease proved more intractable in some than in others; but the result of the whole was that both Lime-juice and Citric acid were recommended as effective remedies, and far preferable to the Nitre. "There seems to be," concludes the reporter, "little reason to doubt, judging from the results of these trials, and from others which were not so well conducted, that the alkaline salt has not the antiscorbutic properties which have been ascribed to it." It may be added, that it is apt to disturb the digestive organs, and that it has a disagreeable taste, and is very much disrelished by the patient.

Neither in the blood nor in the food of scorbutic patients is there any marked deficiency of Potash. It would be almost sufficient here to state that the converse has not been proved, but we may go somewhat further than this. Becquerel and Rodier have found that in the blood of scorbutics there is an excess, instead of a deficiency, of the soluble salts of the alkalies. Andral, Gavarret, and Frémy affirm the same. A similar result has been arrived at by Mr. Busk. He finds the proportion of salts in healthy blood to be 6·8 in 1000, whereas in three cases of scurvy occurring on board the Dreadnought, the amounts of the same were 9·5, 10·9, and 11·5. It is unfortunate that the nature of these salts, whether most of Soda or of Potash, was not inquired into. (*Simon's Chemistry, translated by Dr. Day*, vol. i. p. 315.) As to the food of scorbutics, I have already alluded to the statement of Christison, confirmed by general experience, that Scurvy is sometimes met with in individuals of the higher classes, who have long lived on a perfect mixed diet. I have also stated that the food eaten by sailors contains Potash in abundance. In spite of the elaborate and ingenious argument of Dr. Garrod, it seems to me that there can be little or no doubt that the free vegetable acid is the active or curative agent in Lemon-juice and antiscorbutic vegetables, and that Potash is not antiscorbutic in any sense whatever.

But it is probably not only Citric acid that is efficacious, for it appears that some other vegetable acids, and vegetables which do not contain Citric acid at all, may be used with advantage in scorbutic diseases. Various wild herbs, some of which contain Oxalic instead of Citric acid, have from early times been in use among the poor for this purpose. Among these, Dock, Sorrel, Wood-sorrel, and Stonecrop may be mentioned. Such herbs have been long employed, and recommended by authority. Dr. Mead, in 1751, advised the use of Scurvy-grass and Brooklime, both of which contain Citric acid,—also of Lettuce. He likewise made particular mention of the *Herba Britannica*, which seems to have been the great Dock, Rumex hydrolapathum.*

* The same physician appears to have anticipated some of the modern applications of Lemon-juice. He employed it in liver-diseases generally, among which he included a number of dyspeptic and gouty disorders. He gave it in

As bearing on this therapeutic resemblance between Citric and Oxalic acids, it may be observed that Dr. B. Jones has found the former prove poisonous to animals when given in large doses, in the same manner as Oxalic acid. Next in the series, but probably less effective, may be enumerated the other kindred acids. Tartaric acid, as contained in Supertartrate of Potash, as well as in a separate form, has been found of some use in Scurvy. Malic acid, as contained in the stalks of Rhubarb, and berries of the Mountain Ash, is likewise possessed of some antiscorbutic virtue. It exists in the juice of Apples. Dr. Huxham (*On Fevers*, p. 262) recommended Cider in Scurvy. The advantage of Acetic acid, or Vinegar, in the treatment of Scurvy, has been much debated. It has probably some remedial influence, but is less active than the rest.

To Lactic acid, the interesting animal analogue of the vegetable acids, the same power probably extends in a certain degree. By reference to this acid, some have explained the alleged antiscorbutic properties of milk,—supposing that it turns sour in the stomach. And it is curious to read that an old naval physician, Dr. Harness, was accustomed to cure scorbutic ulcers by the local application of the sour gastric fluid of herbivorous animals. (*Dr. Duncan's Annals of Medicine*, 1797.) Lactic Acid is contained in the juice of flesh; and in certain cases of Scorbutus fresh meat is recommended by Dr. Christison.

It is almost needless to observe that as Citric acid and Lemon-juice are remedies of such acknowledged value, and these other agents confessedly inferior in efficacy, it would be

six-drachm doses; and says that he employed also in similar cases *saponaceous* medicines, and rhubarb. These remedies, apparently heterogeneous, were recognised, then as now, to be useful in the same cases. For we have just seen that Lemon-juice, Alkalies, Cholagogues and Tonics, are all more or less applicable in diseases of the Arthritic group.

most unwise in the physician to resort to the latter in the treatment of Scorbutic disorders, except in peculiar forms, or in eases where the former cannot well be obtained. But the analogy between the operation of these various but similar acids is at least a matter of great scientific interest.

These acids cannot remain in the blood. They pass out of it, and add nothing to it. But they cure Scurvy, and they doubtless act on the Catalytic principle. Scurvy, or Purpura, is an active cachexy, not a passive one, like Anæmia. It requires a Catalytic agent to counteract it; not a Restorative, simply supplying something to the blood. Such an agent is the vegetable acid. It seems in such cases to exert a purifying power over the blood, of the exact nature of which we are not aware.* The scorbutic cachexy is probably not the only one which is thus combated. The great depression and accompanying flux of the tissues which results from the epidemic cold called Influenza, is wonderfully controlled by a vegetable acid. Lemon-juice and Orange-juice are popular remedies for this disorder.

In some cases of Syphilis a cachectic or scorbutiform condition of blood is apt to obtain, and in such Dr. Hauschmann, of Vienna, has found in fresh Lemons a valuable adjunct to mercurial treatment. (*Wiener Med. Zeitung*, No. 42.)

The Epidemic of boils (*Furunculoid*) which of late years has been not unfrequent in England, seems to depend on a scorbutic tendency of system engendered by malarious influence. On this principle vegetable acids have been given, and with much advantage.

It is probable that Asiatic cholera may consist essentially in a rapid and fatal degeneration of the blood, produced by

* "Can we at will, by therapeutic agents, produce a depurating effect on the system, and, by hastening the metamorphosis of matter, aid the removal of a *materies morbi?*"—*Dr. Golding Bird, Lancet*, Feb. 15, 1851.

some septic influence. And there seems to be much reason for supposing that those who are accustomed to the use of the vegetable acids as articles of diet, as in the cider districts of England, are rendered thereby less liable to the attack of this disease. The evidence on this point has been well summed up by Mr. Tucker, in a paper on the subject which he submitted to the Epidemiological Society in 1854.

Ord. VI. Antiperiodics.

PREPARATIONS OF ARSENIC. ALUM? CHLORIDE OF SODIUM?

Periodic disorders are known to be attributable to the entrance into the blood of a peculiar aerial poison. The mild malaria of England excites a comparatively tractable ague; that of the Maremma and of the Pontine Marshes, in Italy, brings on very fatal fevers; while the remittents that are due to the exhalations from the ground on the West coast of Africa and in the West Indian Islands, are of a still more virulent nature. Accurate observations have shown that they are all caused by the exposure of the system to this poison, and by its working in the blood.

Certain mineral medicines of the Catalytic division are employed in the treatment of periodic disorders.

Arsenic is a medicine of considerable power, which, when given in too large a dose, or indeed when given at all in most cases, becomes a poison. It acts in the blood, and produces in it a number of effects of a particular kind. When given in slight excess, it is apt to bring on œdema of the face, and redness of the conjunctivæ. Besides causing various nervous disorders when in large doses, its continued use may bring on a cutaneous eruption, described by Mr. Hunt as a kind of pityriasis, together with a failure of appetite, general depression, a quick, small pulse, hurried respiration, and sometimes swelling of the feet. Any kind of eruption would alone constitute sufficient proof of an operation in the blood.

One part of this operation is that it is capable of antagonizing the poisons of intermittent disorders, as also of certain convulsive affections and skin-diseases. In health a poison, in disease it proves a remedy. But the dangerous nature of its action is such as to demand considerable care in the administration of the preparations of Arsenious acid.

Dr. A. T. Thomson states that the action of Arsenic is liable to exacerbations and remissions, and sometimes even intermissions. Thus we may suppose that there is a certain degree of analogy between its operation and that of the malarious poison, by virtue of which it may perhaps exert a corrective power over the working of the latter in the blood. (*Vide* page 206.) Such an analogy could only exist in the case of a Catalytic medicine. It is not observed of Quina, which is employed in intermittents on the Restorative plan. Arsenic is foreign to the blood, and is in every way a Catalytic medicine.

In large doses Arsenical preparations act on the stomach as irritant poisons. Some of them have been used externally as Caustics, especially in Lupus. But this is a kind of action that does not concern us now.

The officinal solution of Arsenite of Potash was introduced into notice by Dr. Fowler, and is the chief preparation of Arsenic employed. De Valangin's solution contains a Terchloride of Arsenic, and is of less than half the strength of the others. Both of them are used in Ague. Some recommend, in all cases where Arsenic is used, to begin with small doses, as two drops of Fowler's solution three times a day, and gradually to increase the quantity; from the idea that the system will thus be enabled to tolerate the remedy better, and that irritation of the stomach will be avoided. Mr.

Hunt deprecates this practice, and recommends regular doses of three to five drops, or more. It may be safely continued during the paroxysm of Ague, which is a plan that is generally considered to be unadvisable in the case of Quina. The latter may be given in a very full dose between the paroxysms; but this cannot be done with Arsenic, for the consequences would be dangerous. It is best in all cases to give the Arsenic after a meal, on a full stomach, as then it is less likely to irritate, not coming directly in contact with the coats of the stomach, and being diluted by the food during its absorption.

Arsenic is useful in other intermittent disorders besides Ague, as in the various kinds of intermittent neuralgia. It has been given in some varieties of intermittent pulse which are not due to organic diseases of the heart. Dr. Darwin cured a case in which the beats of the heart intermitted regularly once in every three or four times, by the administration of four drops of a saturated solution of Arsenious acid three times a day.

The preparations of Arsenic have even been used in some cases of Gastrodynia with considerable advantage. In these instances the disorder of the stomach generally assumes an intermittent form It has been supposed by some that Arsenic in such disorders acts directly upon the nerves; but it appears to counteract all the manifestations of this intermittent poison, whether local or general, by the same action in the blood.

Several attempts have been made at different times to discover a substitute for Arsenic, and a cheaper remedy than Quinine, for the treatment of Ague. Iron is employed with advantage in old chronic cases attended with Anæmia; but it is not of service by counteracting the intermittent, but by remedying the anæmic condition which coexists with it.

M. Piorry, in the course of some experiments made at the Hôpital de la Pitié at Paris, has found common salt in half-ounce doses to be very efficient. In his opinion it is more efficacious than Arsenic, and second only to Quinine, in the cure of this disorder. The suggestion is a valuable one; but the dose is very bulky, and it would be difficult to prevent it from causing vomiting in many cases.

Alum is another medicine which has been recommended in Ague. It also appears to act on the Catalytic plan; but it has not been often employed.

The compounds of Arsenic are found to exert a curious antiseptic influence on dead animal tissues. They particularly prevent decomposition in animal membranes, by virtue of a combination which Arsenic forms with Gelatine. Liebig has founded on these facts a theory of the medicinal action of Arsenic. (*Anim. Chem.*, part i. p. 206.) He supposes that such substances as Arsenic and Mercury may be able to arrest contagious and other disorders in the system in the same way that they control putrefaction out of the body. The use of Salt and Alum in Ague might seem at first sight to countenance such a hypothesis as applicable to the treatment of this disease. But we know that Arsenic does not stop all fermentations. The grain of wheat will germinate, and its starch be converted into sugar, after it has been steeped in a solution of Arsenic to protect it from vermin. And Gelatine, for which Arsenic has an affinity, has not been proved to exist in healthy blood.

The compounds of Mercury, the operation of which in Syphilis is sought to be explained on these grounds, are not nearly so antiseptic as many other minerals. If this theory were correct, then all Catalytic medicines, and all antiseptic substances, should be of equal efficacy in all morbid processes. But this is far from being the case. Many substances which are distinguished for their antiseptic powers are found to have no influence whatever on the progress of these disorders. Are Acetic acid and Creosote of any use in Ague? Does

Alcohol prevent the drunkard from contracting Syphilis? And if Arsenic, Alum, and common salt, act solely by arresting fermentation, how is it that they have no control over the supposed fermentations of Syphilis and other diseases? The explanation required must needs be more specific and particular.

ORD. VII. ANTICONVULSIVES.

PREPARATIONS OF ARSENIC, SILVER, ZINC, LEAD, AND COPPER.

The *Convulsive* disorders that are under the influence of Blood-medicines are associated with, or dependent on, a deterioration of blood of a peculiar kind. Although these diseases are manifested either by a derangement of the nervous system in general, or by a disturbance of the funtions of the brain or spinal cord in particular, yet they are very rarely accompanied with an appreciable nervous lesion. When this is the case, as in the instance of Tetanus, which may arise from a mere irritation of the end of a nerve, they are extremely intractable. Epilepsy, too, may sometimes be due to a bony spicula, or tumour in the brain, or to the irritation produced by intestinal worms in children; but these direct nervous causes of such convulsive disorders are only occasionally met with. I believe that they are oftener connected with a diseased condition of the blood. It is probably only those which are thus connected with blood disorder, that are under the influence of blood-medicines. Those arising from a nervous lesion are more or less beyond their control; and this we know to be the case with a considerable proportion of such spasmodic diseases.

Epilepsy and Hysteria are frequently inherited. This supplies us with one argument. They are also apt to be brought on by various depressing causes which affect the system in general. The strumous diathesis, which originates in the fluids, and not in the nervous system, is affirmed by Dr. Cheyne and Dr. Watson to be a powerful predisposing cause of Epilepsy. The retention of Urea in the blood, occurring in some kidney diseases, will cause the same disorder. Hysteria is very often associated with Anæmia. Tetanus, even, depends very much on certain atmospheric conditions. There are sometimes, as it were, epidemics of Tetanus, in which the slightest abrasion will suffice to bring it on among the people residing in a particular neighbourhood. It is often rife in one district for long together. Facts like this must certainly be regarded as pointing to a condition of the blood as one, at least, of the causes of this terrible disorder. This condition of the blood may react upon the nerves, and maintain in them a particular morbid state. Chorea seems also to depend primarily on the state of the blood, and is indirectly curable by medicines which, like Iron and Quinine, improve its condition. It is often associated with Rheumatism. In a weakly and strumous child, it may be brought on by a sudden fright, which would not affect one of a good constitution.

We might conclude from these facts alone that the blood is often the seat and origin of these diseases.* But there is yet a stronger reason to induce us to suppose that they are frequently produced by some poison in the blood which acts on and disturbs the nervous organs, without perceptibly altering their physical construction. Many medicinal substances present us with an artificial illustration of this action. Lead, Copper, Mercury, and Arsenic, by their presence and operation in the blood, are capable of causing severe and chronic nervous disorders, particularly Paralysis and Epilepsy. Many of the vegetable Neurotics, after their passage into the blood, bring about transient nervous symptoms, which are identical with those of disease. Thus Opium produces coma; Belladonna, delirium; Aconite and Hemlock, paralysis; Hydrocyanic acid, convulsions; Indian hemp, catalepsy. When the cause of these affections is removed, the symptoms disappear; when the case returns, the symptoms return. The same is apparently the cause with those unknown animal poisons that operate so as to produce nervous symptoms, without a nervous lesion.

These convulsive disorders may be treated in either or both of two ways. We may attack the supposed cause in the blood by employing one of the mineral Anticonvulsives, or we may simply apply our remedies to the nervous system, the more immediate seat of the morbid manifestations, and adopt a palliative or defensive course.

* In confirmation, see *Romberg on Nervous Diseases* (Syd. Soc.), vol. ii. pp. 184, 185; *Dr. Watson's Lectures*, vol. i, p. 637 *et seq.; Dr. Todd's Clinical Lectures on Nervous Diseases*, p. 459; *Dr. Williams' Principles of Medicine*, 2nd ed. p. 97; etc.

The metallic salts used as *Anticonvulsives* are all capable, when taken for some time, of causing a deterioration of the blood. This is the most apparent in the case of Lead, which besides a number of nervous symptoms, tends to bring on a kind of jaundice, with general wasting of the body. In patients suffering from Saturnine cachexy, Andral and Gavarret found a deficiency of corpuscles in the blood, and observed an unnatural yellowish colour of the serum. Chronic poisoning by Zinc and Copper resembles that by Lead. The symptoms of what is called "Zincal intoxication" were recently described to the French Academy by M. Landouzy of Rheims, as occurring constantly among the zinc-workers. There was sometimes an œdema like that produced by Arsenic.

The production of all the known nervous disorders by the presence in the blood of different metallic medicines, gives a strong additional probability to the belief that these disorders, when occurring spontaneously, are in many cases due to the presence in the blood of some unknown poison.

I am able to add little respecting the rationale of their action to that which I have said of the operation of Catalytic medicines in general. It is certainly very mysterious; and it is perhaps mainly on this account that some have been induced altogether to deny it. But a denial so grounded is disingenuous and wrong, for we must often be content to know and to receive many things that we do not understand.

Convulsive disorders, as I have just said, are in some cases entirely dependent on a condition of the nervous system. In other cases they are mainly connected with a certain state of the blood. Disorders of the first kind are probably not at all under the influence of these Catalytic medicines. But the more decided the connexion between any of these diseases and the condition of the blood, just so much the more marked is the power over it possessed by a medicine of this group of Anticonvulsives.

Perhaps the most evident and characteristic of these agencies is that of Nitrate of Silver in the cure of Epilepsy. The Acetate of Lead, and the Ammonio-sulphate of Copper, have been used with advantage in the same disorder. Dr. Babington strongly recommends the Sulphate of Zinc, given at first in small doses, and then gradually increased, so that it may not produce vomiting.

In the treatment of Chorea, Arsenic is highly esteemed and recommended by Dr. Pereira.

In Hysteria these medicines are all probably more or less applicable; but on account of the obstinate and multiform nature of this disease, their use in it is less obvious than in Epilepsy and Chorea. Hysteria, too, is more under the influence of Nerve-medicines than are the other two diseases.

The great objection to Silver, in whatever form given, is that its salts are liable to be reduced in the system, and it thus tends to produce a permanent discoloration of the skin, either browning it or communicating to it a dull leaden hue. This naturally constitutes a strong ground of objection with the unfortunate patient, who would often prefer to be left alone with his fits than to be turned blue for life.

Dr. A. T. Thomson recommended the combination of the Nitrate of Silver with an excess of Nitric Acid, fancying that this would prevent its precipitation by chlorides in the blood, and subsequent de-oxidation. But, as is reasonably objected by Patterson and Mialhe, the precipitation of Silver by chlorides takes place in the presence of free Nitric acid. This mode of preventing discoloration is therefore valueless.

As the black subchloride is decolourized or decomposed by Iodide of Potassium, Dr. Patterson has recommended this salt as a cure for the blackening caused by a course of Silver. The Iodide of Silver produced being unfortunately again blackened by the action of light, this cure also must be discarded. Trousseau and Pidoux have tried it, as might be supposed, without effect.

After all, the surest way to prevent the chance of this objectionable discolouration is to intermit or suspend the use of the medicine after two months. Dr. James Johnson states that there is "not an instance on record" where the complexion has been affected by the remedy when restricted to "three months' administration."

The Nitrate should be given in solution, when the stomach is empty. After entrance into the blood, its decomposition by the alkaline chlorides is inevitable, but if this takes place in the stomach by contact with the food, absorption will be seriously retarded. The chloride being insoluble, is far less active as a remedy than the Nitrate.

M. Georget supposes that the advocates for the use of Nitrate of Silver in Epilepsy employ it on the principle of counter-irritation, saying that they attempt to cure a diseased brain by cauterizing the stomach. (*Physiology of the Nerv. System*, vol. ii., p. 401.) But I am not aware that any English therapeutists have adopted this view of its mode of operation. The dose of the Nitrate of Silver, and the state of dilution in which it is given, would certainly prevent it from manifesting any such action. And we should not be warranted in supposing that any of the medicines of this or any other order of Catalytic remedies could act in so direct and so easy a way as that, even if it were possible.

Some have supposed that Nitrate of Silver cures Epilepsy by diminishing an irritable condition of the stomach. But it is observed by Dr. Pereira that the existence of this irritability in all cases of Epilepsy is a mere assumption. The solution of this salt exerts, according to its strength, an astringent or caustic action on all mucous surfaces, and thus improves their condition when they are relaxed, inflamed, irritable, or ulcerated. The occasional benefit which follows the administration of the preparations of Silver in Gastrodynia may be referred to an action of this kind. The action of Arsenic in some intermittent varieties of this painful affection has already been mentioned, and is explained in another way. Caustic substances probably act locally in these cases; but Arsenious preparations exert an Antiperiodic influence in the blood generally.

Tetanus is by far the most incurable of these convulsive disorders. Arsenic and other medicines of this order have been recommended in the treatment; but although some cases appear to be partly connected in their first origin with a certain condition of the blood, this disease is very little under the influence of blood-medicines, or indeed of any medicines at all. Neurotics can only combat a functional error; they are powerless against organic derangement. So that when we find a convulsive disorder that depends simply and solely upon a nervous lesion, we shall in most cases have to confess, to our misfortune and sorrow, that it is entirely beyond our control.

Ord. VIII. Antisquamics.

PREPARATIONS OF ARSENIC. SULPHUR, AND ITS COMBINATIONS. PITCH AND TAR.

Skin diseases are both caused and cured in a variety of ways. Some are produced by external influences. They may be brought on by mere irritation, as certain kinds of Eczema and Herpes, and are then to be treated with soothing unguents or cool lotions. Or they may even be connected with some external organization, of a vegetable or an animal kind, as Porrigo and Favus are traceable to a parasitic fungus,* and Scabies is accompanied by the development of a species of Acarus. Others are due to some wrong in the digestive process, or to a plethoric condition of the system. Urticaria is an example of the former, Acne of the latter. They may generally be treated most effectually by the exhibition of salines and rhubarb.

A third class of skin diseases are due to the existence in the blood of certain poisons or peculiar morbid conditions. The eruption may constitute one only among many symptoms of the action of this poison, or it may be the chief or only symptom. The former is the case in Syphilis and the Eruptive fevers. It is with the latter kind that we are now concerned.

There are two modes by which we may get rid of the poison that causes the eruption,—Elimination and Counteraction. The first may sometimes be effected by the use of Purgatives, Sudorifics, or Diuretics.

But I have classed in this last order of Catalytic blood-medicines some remedies that have proved useful in counter-

"The vegetable organisms found in diseases of the skin are not to be looked upon as the origin of the disease, but as being developed in textures previously morbid."—*Dr. Balfour*—(*Outlines of Botany*, p. 365.) I also very much doubt whether these eruptions, at least in all cases, are dependent solely upon the Fungi, which perhaps may often be a symptom, and not a cause. I believe the above-mentioned disorders to be generally more or less under the influence of Antisquamic remedies.

acting the causes of these diseases. The eruptive disorders alluded to are all connected together both in their symptoms and treatment; but because the squamous diseases, Lepra and Psoriasis, are the most characteristically under the influence of these remedies, the latter have been named Antisquamics.

Arsenious acid,* as contained in Fowler's solution, a remedy already twice named among Catalytics, is also the most powerful of these Antisquamic agents. Mr. Hunt considers it to be a specific for all skin diseases that are not syphilitic in their origin. Besides Lepra and Psoriasis, it is found useful in Eczema, Impetigo, and Lupus. In the last disorder it has been used both externally and internally, seeming to be in both cases specific in its action. Thus we find in these skin diseases another special antagonism for this extraordinary medicine, which has already been shown to be of considerable efficacy both in periodic and convulsive disorders.

Pitch or Tar is another remedy which seems to be capable of counteracting the scaly disorders. It may be either applied externally, or given internally, in doses of ten to twenty grains. It has been recommended for employment in some of the other skin diseases, but its advantage in them is not so obvious. When it is applied to the skin, some one or more of its principles becomes absorbed.† Pitch, as a remedy for Lepra, is comparatively of recent introduction, but its efficacy has already been very widely acknowledged. Whether it acts as a cutaneous stimulant, or, as a diaphoretic, eliminates by the skin a *materies morbi;* or, whether its action is that of a true Catalytic in the blood, is not clear.

Tincture of Cantharides and Acetate of Potash, both diuretics, have been employed in Lepra to eliminate the morbid

* According to Prof. Wilson, the ancient Hindoo physicians employed this remedy in Lepra, as well as in intermittents.

† Dr. Petters has discovered Carbonic acid in the urine, in combination with Soda, after frictions of Tar. (*Quarterly Journal of Practical Therapeutics*, iii. 1855.)

material from the blood into the urine, and have sometimes appeared to succeed in so doing. But in this, as in many other cases, counteraction is both easier and more certain than elimination. The system itself naturally attempts this elimination, and when it finds it impossible, we often gain nothing by urging it.

I need scarcely say that these remedies are applicable only in simple Lepra and Psoriasis, and not in the syphilitic forms of those eruptions, which are treated best by Mercury, or by other medicines of the second order of Catalytics. These Syphilitic eruptions are distinguished by a coppery or a livid-grayish colour, and by the absence of itching.

Sulphur has been used with benefit in Eczema, Impetigo, and Lepra. It may be administered externally in the form of fumigation or ointment, or internally in combination with an alkali or with Iodine. In the case of Eczema and Impetigo, the fumigation and internal administration are preferable, as the ointment is apt to increase the existing irritation. In the cure of Lepra the mineral waters of Harrogate and other places, containing Sulphuretted Hydrogen gas, have been much recommended.

Sulphur is a diaphoretic; but other more powerful diaphoretics are destitute of power over these diseases, and Sulphur does good without obviously exciting the functions of the skin. It effects changes in the blood, inasmuch as it is found to combine there both with hydrogen and oxygen, and to carry them out of the system as sulphuretted hydrogen and sulphuric acid. Dr. Pereira and others ascribe to Sulphur a resolvent and liquefacient action.

We have in Sulphur a decided Antisquamic medicine. It is more or less useful in all non-syphilitic cutaneous disorders. Dr. Burgess has found sulphur ointment and fumigations to be very useful in Psoriasis palmaris. (*On Eruptions of the Face, etc.*, p. 229.)

Though Sulphur seems to act specifically in the treatment of these disorders, there is another disease of a similar kind which it has been supposed to cure by a mere external agency. This is Scabies. Some have always fancied that even here it acted specifically, and that this also was a blood-disease. But Scabies has long been attributed to an external cause, an insect, or, more correctly, an arachnid, which, by burrowing in the skin, is thought to produce the vesicular eruption. The Acarus Scabiei, or Itch insect, was discovered in 1179 by Abenzoar, the Arabian. In 1687 Dr. Giovanni Bonomo wrote a full account of it in a letter to Redi of Florence. It has been supposed that Sulphur ointments and Sulphur fumigations have a direct external action in causing the death of this Acarus, by the bodily transmission of which from one person to another the contagious nature of the disease is accounted for.

Dr. Billing considers that the confirmation of this discovery has given the death-blow to an idea which, I think, will last as long as medicine; viz. that certain remedies exert a special influence in the cure of particular diseases. (*Principles of Medicine*, p. 75.) But we must not deny the existence of special agents, simply because we cannot understand their operation; for it is apparent in too many instances. And from the circumstance that Sulphur has proved beneficial when given internally in Scabies, as well as the fact that this disease has often an idiopathic origin, I am disposed to doubt the value of the inference which is drawn from the discovery of the Acarus, and I still conceive that Sulphur exerts an action of a specific kind in this disease as well as in the others. This, too, is the opinion of many writers on the subject of skin diseases; among others, of Dr. Burgess, an accurate and experienced observer. (*On Eruptions of the Face, etc.*, 1849.)

"Several eminent dermatologists, who admit the existence of the Acarus in Scabies, will not allow that it is the cause of the disease, but merely an accompanying phenomenon. This is my opinion also." (p. 239.) "I believe that the Acarus, and the vesicles and pustules which he undoubtedly produces in the skin, are, one and all, symptoms of some peculiar disordered condition of the system, which we are as yet unable to explain." (p. 233.) We may believe this without committing ourselves to the Hahnemannic absurdity about *Psora*. The Sulphur which cures the disease may be admitted into the system by absorption, when applied externally. That it is this Sulphur which kills the itch insect is an assumption not quite borne out by the results of experiment. M. Griffi, of Sardinia, and Dr. Bennet, of Edinburgh, have both succeeded in killing the vermin and removing eruptions by the simple application of Lard or Oil, which is supposed to kill the Acarus by stopping its respiratory pores. (*Monthly Journal*, Jan. 1850.) So it may, they argue, after all, be the Lard which is the efficacious ingredient in the Sulphur ointment.

Some other internal remedies, and many other external applications, have been used in skin diseases; but these that I have mentioned are the only ones that appear to exert something of a special action in all cases. Arsenic is perhaps the most universal in its application. It often happens that when this remedy entirely fails, the eruption is connected with a constitutional taint of Syphilis. When there is a suspicion of this, such a remedy as Donovan's solution, containing both Arsenic and Mercury, is peculiarly applicable, because capable of acting in a double way. This medicine also contains Iodine; and either this preparation, or the Iodide of Potassium, should be prescribed when the skin disease appears to be connected with a strumous diathesis.

As soon as the course of Arsenic is found to produce swelling of the face or irritation of the conjunctivæ, symptoms which denote the saturation of the system with the remedy, its administration should be suspended for awhile.

We have now concluded the subject of Hæmatic medicines. I have said that this class has been very generally neglected and overlooked by writers on the subject. For this reason, and because there are some ideas respecting their action which I have thought it worth while to work out and to investigate at some length, I have devoted more space to its elaboration than I shall be able to spare for either of the remaining classes, in the consideration of which we are not likely to encounter so many interesting and debateable points.

PROP. VIII.—*That a second class of medicines, called* NEUROTICS, *act by passing from the blood to the nerves or nerve-centres, which they influence.*

1. *That of these some, called* STIMULANTS, *act so as to exalt nervous force, in general or in particular.*
2. *That others, called* NARCOTICS, *act so as first to exalt nervous force, and then to depress it; and have also a special influence on the intellectual part of the brain.*
3. *That others again, called* SEDATIVES, *act so as to depress nervous force, in general or in particular.*

Having investigated at some length the action of Blood-medicines, we now commence the consideration of another class of remedies, which differ very widely from the last in their mode of operation.

The action of Hæmatics is slow, but more or less durable, because it is evidenced in the blood; and a change in the blood produced by this action continues for a longer or a shorter time.

The action of Neurotics, or Nerve-medicines, is rapid; but it is transient, and is soon over. A Neurotic medicine does not cause any change in the blood; and it cannot remain in it, but soon passes out. It acts by contact with nerve, apparently producing no lasting change even in nerve-fibre: and as the cause of the action cannot remain, the effect also soon passes away. Whereas Hæmatics, durable agents in the blood, are used to counteract the causes of inveterate and chronic disorders; these Neurotics, which produce a transitory, but more or less forcible impression on the nervous system, are employed to rouse it when torpid, or to depress it when over-excited. Hæmatics are used to control diseases; Neurotics, to counteract symptoms. Rarely of use in chronic blood-disorders, they are given mostly in the temporary emergencies of acute diseases. But it is obvious that even a temporary agent may prove of permanent efficacy by remedying a temporary emergency.

It was feasible to attempt some explanation of the actions of medicines in the blood, occasionally more or less analogous to known chemical influences. But the agency of nerve-medicines is of a far more incomprehensible kind. When we consider that little or nothing is known, or can be known, about the ultimate causes of sensation, or motion, or nervous excitement, there is no need for wonder that we find ourselves at a loss to explain the operation of medicines that influence these conditions.

Thus I must chiefly limit my remarks on Neurotics to defining *what* their action is, finding it impossible to state with certainty *how* they act. And the field of inquiry being so limited, it follows that there is much less to be said about them than had to be said of Hæmatics.

Nearly all the powerful poisons that act after passage into the blood, belong to this class. Their action in most points of view is such as completely to exceed our means of comprehension.

Sudden death may be produced by it. But there is no apparent cause for this. We find no erosion or perforation of the coats of the stomach or intestines; no mechanical disorganization of the tissues, or chemical change in them; no hemorrhage, or vascular disease; no rupture of nerve-fibres. Whence then could death have arisen? How could the mere presence of a few atoms in the blood,—half a grain, one-twentieth, or even one-fiftieth of a grain,—how could this apparently contemptible influence have produced so essential a derangement of the vital functions, as to stop them altogether? It is impossible to answer.

The action of such remedies in the sudden causation or alleviation of nervous symptoms, when applied in the cure of disease, is equally wonderful. How are we to account for their different actions on different nerves? How is it that Opium contracts the pupil, and Belladonna dilates it?—that Digitalis affects the heart, and Stramonium the Respiration? —that Prussic acid will cause convulsions, and Hyoscyamus delirium? In what way are these various operations brought to pass? It is impossible to answer.

Though it is, I say, quite impossible to frame for any one of these questions a certain or satisfactory reply, on account of the manifest insufficiency of our acquaintance with the details of such actions as these, yet I may now venture to repeat an idea which I have already referred to at the commencement of this Essay (p. 49,) and state my belief in the bare possibility of the operations of Neurotic agents being explicable upon mechanical grounds. It is generally believed among scientific men that each particle of a compound body is made up of a number of indivisible atoms, each of which is inconceivably minute in size. And as these compound bodies have each a peculiar chemical constitution, so must each of their ultimate parts be composed of a peculiar arrangement of simpler atoms, and thus have a certain shape of its own, more or less different from the shape of every other compound atom. Both the substance of a nerve, and the active part of a nerve-medicine, consist of a number of definite compound atoms. And it is possible that the atom of a stimulant medicine may be of such a shape as that it shall be unable to coincide with, or to fit into, the series of atoms forming the sensitive surface of the nerve, and thus irritate this when brought into contact with it; and that the compound atoms of a sedative may so arrange with these nerve particles as to fit among and extinguish the salient points, and annihilate their natural sensibility. We learn from the phenomena of the senses that the nerves are very much under the influence of mechanical impulses of all kinds, and particularly minute and inappreciable impulses of this description. Another fact which gives additional credibility to such an idea is, that those Neurotic substances which are chemically alike are in general alike also in their influence on nerve.

The particular way in which nerve-medicines affect different parts of the nervous system might perhaps be explained by supposing minute chemical differences in the composition of the atoms of which those parts are constructed, sufficient to alter their relations to the atoms of certain remedies. If we adopt the Atomic theory, we must perceive that no two chemical bodies can be precisely alike in the shapes of their particles. This various dissimilarity might throw some light upon the many shades of distinction between the operations of Neurotic medicines on different parts. Thus, as a general rule, both Morphia and Atropia are paralyzers of motor nerves. But they do not act alike on the Ciliary nerves by which the motions of the Iris are controlled. We may suppose that there is a certain chemical peculiarity in the particles of these nerves, by which they are enabled to coincide with the atoms of Atropia, and are thus blunted and paralyzed by them; but are, on the contrary, stimulated and excited by the atoms of Morphia, which have the contrary action, because unable, on account of their relative shape, to dovetail with these atoms.

This idea is, as I have said, purely conjectural and fictitious, and is indeed likely to remain so; for the thing is not by its nature susceptible of proof, nor is it even possible to inquire into it. And I have only thought it worth while to explain it at length because it is desirable that every statement which is made, however improbable and unworthy of credence it may seem, should at least be placed in as clear a light as possible.

A chemical theory has been lately suggested to account for the action of Narcotics in particular. It is an explanation to which I cannot give my own adhesion. (See below.)

The action of a Neurotic is readily distinguished from that of Hæmatic medicines by the fact of its exerting a rapid and well-marked influence of some kind on the nervous system. As it is impossible that the medicines contained in this class should remain in the blood, they therefore pass out of the blood through the glands, and in so doing generally act as Eliminatives. This their secondary action will be subsequently considered. It is generally of less importance than their action on nerve; with the exception of some which, as volatile oils and resins, exert a very feeble Neurotic action, but are comparatively powerful as Eliminatives. In this case the secondary action becomes the more important of the two.

As regards the effect on the systems of different animals, or different human beings, we find a far greater variety of action among Neurotics than among Hæmatics. The reason of this is simple. With an Hæmatic the variety of action depends chiefly or solely on the varying conditions of absorption. When it has once entered the blood, the operation of the agent, being quasi-chemical, is subject to fixed laws, and exerted in all cases the same. There is no possibility of the system becoming accustomed, or insusceptible, to the poisonous action of such a drug. But nerve-medicines display no such invariability of action. According as the nervous system, on which alone they act, is susceptible or otherwise, so are they powerful, or the reverse. Thus Opium, which is poisonous to man, is innocuous to certain quadrupeds. Quassia, which to the human system is not Neurotic, becomes so to the system of insects. And as the nerves become habituated to the action of such an agent, they are enabled to bear it better. It is not chemical, but dynamical, or dependent on vital excitability. This explains what is called the *toleration* of nerve-medicines, observed when the same drug has been given for some time.

The most dangerous symptoms of disease are evidenced in the nervous system. Neurotics are employed to control these symptoms as they arise, but Hæmatics are used to combat the cause of the disorder. As to their relative efficacy, there is an advantage and a disadvantage on each side. On the one hand, nerve-medicines are more numerous and more powerful than blood-medicines, and thus in the control of symptoms they are wielded with more immediate certainty than the others in the counteraction of diseases. On the other hand, the symptom that is dreaded is only relieved for a time by the Neurotic remedy, while the morbid condition that caused it continues, and will perhaps cause it again; but when a disorder is remedied by the employment of Hæmatic medicines, it is more or less permanently cured and put an end to.

In the above Proposition I have endeavoured to state as much as we know with certainty of the action of Neurotics. To this certainty I have already ventured to add a surmise, on which no certain reliance can be placed. But even if the theory of the action by atomic shapes should be rejected as improbable, because affording too easy an explanation of a naturally inscrutable operation, it would still seem likely that these medicines may take effect by exerting some minute and imperceptible influence on nerve-fibre, or producing in it some inappreciable disorganization or change, which has the effect of altering the natural performance of its functions. The effect of mechanical concussion or shock, which may produce death by minutely disarranging the particles of the nervous centres, presents an obvious analogy to the sudden and remarkable action of some nerve-poisons.

Having offered these vague suggestions as to the ultimate *modus operandi* of Neurotics, I will now proceed to divide the Proposition in which their more obvious action has been stated into a number of minor propositions. These apply to the whole class. The three divisions will be afterwards shortly considered separately.

m. p. 1.—That Neurotics are medicines which pass into the blood.

m. p. 2.—That their action is evidenced by a change in one or more of those functions which are attributed to the nervous system.

m. p. 3.—That it is necessary that they should pass from the blood to that part of the nervous system which is influenced by them.

m. p. 4.—That they are of use in an over-excited or depressed state of the nervous system.

m. p. 5.—That they are transitory in action, and cannot remain in the blood.

Some space and labour was required in the proof of the minor propositions relating to Hæmatics, for among them were included some things that are not universally acknowledged; but the above account of the action of Neurotics concerns matters that are very generally admitted, and will not occupy us nearly so long in its discussion.

In the first place, it is affirmed that Neurotic medicines pass into the blood. In the consideration of Prop. II. it was shown that all of them,—whether vegetable alkaloids, volatile oils, resins, or mineral substances,—were more or less capable of being absorbed. That they do pass into the blood is proved by the fact that many of them have been detected there, as well as found in the secretions into which they must have entered from the blood. Ammonia, Hydrocyanic acid, Antimony, Asafœtida, Turpentine, Alcohol, and Camphor,—all of which are Neurotic agents,—have been chemically detected in the blood by Tiedemann and Gmelin. A still larger number have been discovered in the urine by Wöhler, particularly of volatile oils, and odorous principles. The active principles of Opium, Belladonna, Stramonium, and Henbane, have been detected in the same secretion by others.

Thus Neurotics pass into the blood. That they act after this absorption, and not by contact with the mucous surface, was proved in the consideration of Prop. I.

The second minor proposition is borne out even by the names by which the recognised action of these medicines is distinguished. Considered as a class, they have no action on the blood, but their influence is quickly and obviously exerted on the nervous system, or on the vital functions which are universally attributed to that part of the animal frame. Stimulants are so called because they are found by experience to exalt nervous force; Sedatives, because they depress it. Thus Ammonia is given to prevent Syncope, caused by a weakness or failure in power of the nerves of the heart; and Aconite is prescribed to relieve pain, caused by an over-excitement of the sensory nerves. Though in these examples Ammonia acts on the centre, and Aconite on the peripheral nerves, yet they are both capable of exalting or of depressing nervous force in general. But neither Stimulants nor Sedatives, as defined by me, exert any marked influence on the intellectual part of the brain. They do not affect the phenomena of mind, or of the four special senses which are immediately associated with it. This influence is confined to the intermediate division of Nerve-medicines, called Narcotics. Their general action is evidenced by a short or long primary stimulation,—and a subsequent depression of nervous force, which is also of variable intensity. At the same time they affect the mind in various ways; exciting it, confusing it, or lulling it. Opium and Alcohol are examples of Narcotics. These distinctions are in most cases obvious and well defined.*

* I have just said that Neurotic medicines influence those functions which are attributed to the nervous system. They act directly upon the nerves. A solution of Morphia, applied to a motor nerve, prevents it from conducting a volitional impulse; a solution of Strychnia, similarly applied, increases and exalts that impulse, so as to cause convulsions. Thus there can be no reasonable doubt that they actually influence the nerves. But it is worth while to notice here the curious fact that Narcotic agents have been found to paralyze the irritable or contractile tissues of certain vegetables. Professor Marcet of Geneva first noticed that the vapours of chloroform and ether affected the leaf of the sensitive-plant so as to prevent it from contracting at the touch, but without at the same time perceptibly injuring its structure. I have produced the same effect on a species of Acacia, which naturally closes its leaves at the

The third minor proposition repeats the rule of local access, which has already been enforced in treating of the fifth proposition. It was not necessary to maintain this in the case of medicines acting on the blood; but Neurotic agents must be shown to operate locally on the various nervous organs. I have only to repeat the arguments which were urged before. It is proved that the action of nerve-medicines cannot be propagated by nervous connexion, but that passage in the circulation is necessary; that the course of the latter is sufficiently rapid to account even for the action of Hydrocyanic acid; and that, however near a medicine be introduced to a nervous organ, it does not affect it unless it be allowed to reach it. The nerves are not naturally constituted for the conduction of medicinal impressions, but only for the passage of impulses of volition, sensation, or emotion. And this evidently forms a powerful safeguard to the system against the effects of a poison. The assertion is further maintained by the fact that the action of a Neurotic, when applied topically to the part which it tends to influence, is the same as that which is exerted by it on the same part after absorption. Opium, Strychnia, or Aconite, will evidence their peculiar action, when applied to a bare nerve. And lastly, some nerve-medicines have actually been found after death in the substance of those nerves and centres which have been affected by them during life.

approach of night. The leaf experimented on remained open, while the others closed. After a certain time it recovered. Solutions of Morphia, Conia and other sedatives, have been found to produce the same result. Now the existence in plants of nervous tissues is not usually admitted. How then are we to explain the analogous action of these paralyzing Neurotics on animals and vegetables? Possibly they may be capable of acting directly on contractile or irritable tissues in both cases, without necessarily influencing the nerves in order to produce paralysis. But Strychnia, which of all medicines exerts the most powerful influence (stimulant) over the muscular system, has been determined by the experiments of Matteucci to act on the nerves only,—and not on the muscles, except through the former.

The use of these medicines in the treatment of disease is defined in the fourth minor proposition. They have, I believe, no influence in the blood. They are not employed in slow or long-continuing diseases. Their applications depend on their known physiological tendencies, already stated. Abnormal deviations from the proper functions of the nervous system are rectified by means of the influence which they exert over the nervous organs.

When the powers of life are sinking, the nervous force on which life depends may perhaps be roused by a strong Stimulant, and maintained by its repetition. Sometimes the emergency may be thus postponed, and the danger escaped.

In violent inflammations and fevers, when the action of the heart is so violent, and the nerves that control it so excited, as to place life in peril, we may do good by the administration of a Sedative, such as Antimony or Digitalis, by which the nervous force may be reduced to its proper level.

Narcotics are used in various cases, to cause sleep, or to quiet mental irritability. Both these and Sedatives are employed to alleviate the different kinds of pain.

Neurotics are thus applied to various symptoms, and to many disorders. Their different modes of action will be detailed more at length presently. It must be remembered that all these actions, powerful though they may be, are transitory. The effect produced on the nerve is not a lasting one, and no essential change in the blood is effected by true Neurotics. They are not natural elements of this fluid, but must quickly pass out of it; and they having thus left it, their action also is over. Thus the truth of the fifth minor proposition is plain.

I will now attempt to give a brief but distinct account of the three divisions into which I have divided this class of medicines.

The first division, and the simplest in action, is that of Stimulants.

STIMULANTS.

Stimulants are medicines which pass from the blood to the nerves or nerve-centres, and act on them so as to exalt nervous force, in general or in particular. That is, they may extend their operation more or less to the whole nervous system, having a general tendency to communicate nervous energy; or they may confine their action to particular departments of this system, having no manifest influence on other parts. On referring to the arrangement at the commencement of the Essay, it will be seen that Stimulants are subdivided, according to whether their action is thus extended or confined.

STIMULANTIA.

Ord. 1. Stimulantia generalia.
Ord. 2. Stimulantia specifica.

The first order includes all the medicines that are commonly understood to be Stimulants. But as the remedies of the second order obviously exert nervous force, the term applied to the others on that ground could not consistently be withheld from them, although their action is more limited and local in its nature, being confined to a certain part of the body, and to certain nerves. The same remark may be made of the order of Special Sedatives, which will soon have to be considered.

ORD. I. GENERAL STIMULANTS.

(*Mineral Substances.*—Ammonia and its Carbonates. Phosphorus.

Animal substances.—Musk, and Castor.

Vegetables containing volatile oils.—The aromatic Labiatæ, Compositæ, and Umbelliferæ. Cloves and Nutmeg. Cinnamon, Cassia, Sassafras. Rue, Barosma. The Aurantiaceæ. Canella. Valerian. Mustard. Cajuput and Pimenta. Hops. Juniper. Turpentine. Cardamom. Onion.

Vegetables containing acrid principles.—Senega. Horse-radish. Serpentary. Cascarilla. Pepper. Contrajerva. Ginger. Capsicum. Mezereon.

Resinous substances.—Guaiacum. Mastich, Olibanum, Myrrh, Elemi. Copaiba. Peru, Tolu. Asafœtida, Ammoniacum, Galbanum. Benzoin, Storax. Pine resin.)

This list of General Stimulants is long, but it might even be further extended. The majority are produced by the vegetable kingdom. The acrid principles to which some owe their power are intermediate in nature between volatile oils and resins. Some of them are volatile, like the former; others fixed, like the latter. Some of the resinous products contain also a volatile oil. The principles of Capsicum and Mezereon are very similar in their chemical nature to the true resins. (*Vide* page 97.)

These remedies differ very much in power, but their influence is the same in character. They exalt nervous force in general. They seem to act on the whole nervous system; but their most obvious action is to increase the force and frequency of the pulse, and to invigorate the circulation.* They are not, for the most part, very powerful medicines; and their action is seldom so violent as to be succeeded by much reaction. They improve digestion for a time, by a stimulation of the sympathetic nerves of the stomach and other viscera. In large doses, they are irritants, and may impair the digestive powers and cause headache. Though possessing no marked stimulant power over the function of mind, like that of the Inebriant Narcotics, yet they certainly exalt the activity of the brain, along with the other nervous forces.

Dr. Pereira classes the majority of Stimulants among *Ganglionics*, considering that they only act on parts supplied

* "*Stimulators*, by affecting the nerves, promote a more plentiful *secretion* and *flow* of spirits, whence the heart obtains a greater *force*."—*Boerhaave, Powers of Medicines*, 1727.

by the sympathetic system of nerves. But this view of their operation appears to me to be too limited; for all of them seem to have a certain action on the brain.

Thus Ammonia is used in Syncope, a state which no doubt depends upon a shock received by the brain. And there are several things which show that it relieves this state more by stimulating the brain than by merely rousing the heart and vascular system. It is found to be most effectual when inhaled through the nose; by which means it could easily pass at once into the cerebral circulation.* Dr. Pereira thinks that when administered in the liquid form it can only pass into the blood as a salt, being neutralized by the stomach-acid. In this case it could only act before absorption. But it is probable that it is too diffusible and too rapidly absorbed to be entirely so neutralized; and besides, its operation when inhaled is the same as when ingested, which seems to point to an agency after absorption in the latter case. For when inhaled, it must be absorbed in the free state. And to suppose that it acts by stimulating the nerves of the stomach only, is to receive a thing for which we find no parallel in the action of medicines. (*Vide Prop. I.*)

Ammonia has been used with advantage in the prevention of Epileptic fits, being given just before their expected occurrence. It could hardly be of use in this disorder unless it affected the brain. And of all agents it has the greatest power of removing the excitement or stupefaction produced by the action on the brain of Inebriant Narcotics, such as Alcohol.†

Other General Stimulants manifest this action on the brain to a greater or less degree.

* Dr. Maclagan prefers to believe that it acts, when inhaled, "on the heart and respiration, by a reflex propagation of its pungent impression on the nasal branches of the fifth pair," but he acknowledges that when taken into the stomach it acts after absorption. There seems to be some inconsistency in this.

† See *Journal de Chimie Médicale*, Nov. 1854.

Phosphorus is a Stimulant. In small doses it quickens the pulse. It somewhat heightens the mental activity. It is said also to have an aphrodisiac operation due to its powers as a cerebral excitor. Volatile oils possess a certain influence over the functions of the brain, as well as those of the organic nerves. Cajuput oil has been used in Hysteria; employed to control various spasmodic movements; and administered in Typhoid fevers and Asiatic Cholera, to communicate nervous power. The fetid gum resins are well known as Antispasmodics. The spasms which these medicines relieve are due to a fault in the nervous polarity, commencing generally in the brain or nerve-centres,—and are more or less subdued by general stimulators of the nervous functions. Copaiba, an oleo-resin, may cause a general febrile condition, accompanied with head-ache,—when given in large doses.

So obvious is the cerebral power of some volatile oils, that Turpentine, in large doses, has been known to produce inebriation. It is not generally used for its Neurotic powers, but as a Purgative or a Diuretic; or else it might have been classed among Inebriant Narcotics. I have enumerated it above among volatile oils. It may be regarded as transitional between true Stimulants and Narcotics.

Most General Stimulants are without any marked influence on the mind; but stimulate the organic and merely animal function of the brain, and of the sympathetic nerve throughout the system.

Concluding that General Stimulants have all more or less the power of exalting nervous force in general, we have still to consider some other questions relating to their action.

It is maintained by some that Stimulants have simply the power of calling forth the nervous force which already exists in the system, and that they cannot create any more in addition to this. But if this were the case, then the reaction, or subsequent failure of nervous power, ought to be exactly equivalent to the first temporary increase of that power; assuming this increase to have been simply abstracted from the natural resources. But we do not find it to be so. The reaction from the effect of a Stimulant is always very slight, and often quite imperceptible.

And there seems to be no *à priori* reason why we should not actually cause nervous force to be generated. We know that a galvanic current, or even a mechanical cause, may induce it to be suddenly and powerfully manifested. I believe that a Stimulant is able actually to produce nervous action; perhaps by an irritative operation upon nerve-fibre. So by continually repeating the dose of a Stimulant, as Ammonia or Brandy, it is possible to maintain the circulation and nervous energy at a certain level, without the occurrence of any reaction for a considerable period.

But we must take care not to confound *nervous force* with *vital force*. The former may be very much increased, as in high inflammatory fever, without a corresponding increase of the latter. The advantage of a Stimulant is regulated by this rule. When there is a failure in vital energy, no Stimulant will serve to prolong life, for it cannot communicate fresh vital power. But there may be no such failure of vital energy, and yet a sudden or accidental deficiency of nervous force may serve to peril the continuance of health, or even the tenure of life. For a certain degree of this nervous force is necessary both for life and health. When it is diminished, all the functions must suffer; when it fails entirely the circulation must stop, and death ensues. It is in these cases that a Stimulant medicine is appropriate. It does not do good by communicating vital energy, but by remedying the want of nervous action, by which want the manifestation of the vital energy is subdued. This must always be borne in mind when the applicability of Stimulants is under consideration.

Some writers have complicated the subject by classing as

Stimulants all medicines which tend, directly or indirectly, to communicate vital strength; as Tonics, and remedies which counteract morbid depressing causes. This is in direct contradiction to the rule given above. True Stimulants are only of use by counteracting that failure of nervous force which hinders the manifestation of the vital strength which is stored up somewhere in the system. For I have just observed, that to exalt nervous force is not necessarily to exalt vital force, but that anything which tends to destroy the former must at length repress and extinguish the latter.

The above considerations apply to the action of these Stimulants on the powers of the system generally. But they may act locally. Thus, in moderate doses they promote digestion, by acting on the nerves of the stomach and intestinal canal. They increase most of the secretions in passing through the glands in the blood. In both cases they exalt nervous force; but in the latter case their action is of a particular nature, and will be treated of when they are considered under the title of Eliminative medicines.

To impress the system generally, Stimulants are used when there is a failure of nervous force on account of some sudden and acute disorder, without any material undermining of the vital energies. In long Chronic cases, where there is real and manifest vital debility, Tonics or blood-medicines are required. But in such a case as syncope, or stoppage of the heart on account of a sudden nervous shock, Stimulants are particularly appropriate; also, in the latter stage of Typhoid fever, or of asthenic Pneumonia, or of Cholera, where the existence of life is endangered by a great loss of nervous power. In spasmodic diseases, as Hysteria, where the health is deteriorated on account of a derangement of the nervous functions, Stimulants may be of use.

Such then appears to be the *modus operandi*, and such are the chief applications, of the remedies belonging to the order of General Stimulants. Those of the next order exert an action of the same kind, but their field of operation is on a more confined scale.

Ord. II. Special Stimulants.

(Strychnia. Brucia. Toxicodendron. Veratria. Ergot of Rye. Borax. Rue. Uva Ursi?)

These are medicines which pass from the blood to the nerves or nerve-centres, and act so as to exalt the energy of particular nerves or sets of nerves. They do not affect the whole nervous system; but they operate on one set of nerves in the same way that General Stimulants operate on all, though usually with greater energy.

The causes of such a localized action are hid in obscurity; but it has already been hinted that they may perhaps be partly accounted for by the differences in chemical or mechanical structure existing between different parts of the nervous system.

Strychnia, the alkaloid and chief active principle of Nux Vomica, acts as a Special Stimulant, chiefly to the spinal cord and the nerves that proceed from it. Its operation is mainly exerted upon the motor branches. Thus in large doses it causes a spasmodic and powerful contraction of the muscles of the trunk, and may even produce death by rendering respiration impossible.* Its action is propagated from a motor nerve to a muscle, and is kept up for some time. Matteucci has proved that it is the nerve, and not the muscle itself, whose function is excited by the medicine. In small doses Strychnia is useful in certain cases of paralysis. Two things are necessary in order that it may act efficiently. The muscles of the

* The tetanus produced by Strychnia is distinguished from that of disease by the suddenness and rapid succession of marked symptoms; and by opisthotonos being quickly produced, instead of its being preceded for some time by lockjaw. (See *Strychnia*, Chap. IV.)

part must be whole and sound; for if destroyed by excessive atrophy or fatty degeneration, they cannot be roused by any stimulus. The nerve, too, and the centre from which it originates must be sound, or else the medicinal impulse cannot be conducted along it. These two conditions can only concur in paralysis from disuse, *i. e.* when the incapacity to move a limb depends merely upon its having long been in a state of inactivity, but when the lesion of the centre which caused the paralysis has at length sufficiently healed, and the nerve is now in a fit state to conduct a motor impulse.

Strychnia has no operation on the intellectual functions; neither does it act upon the sympathetic nerves of the heart and arteries, so as to quicken the pulse, like ordinary stimulants. It exalts sensibility as well as irritability, but not so powerfully. It is a Special Stimulant to the motor and sensory nerves throughout the body. Acting upon the spinal cord, it tends thus to exalt reflex action, which is derived from that centre. In small doses it appears to promote digestion, and may perhaps act upon the ganglionic nerves supplied to the stomach.

Brucia, which is the other alkaloid of Nux Vomica,—and the leaves of the Rhus Toxicodendron,—resembles Strychnia in their action, but are less powerful.

Veratria has a stimulant action of the same kind. The operation of this alkaloid has been examined by Messrs. Faivre and Leblanc. They find that it excites the muscular system of the intestines, causing tenesmus and colic, which are succeeded by exhaustion. It also, in poisonous doses, causes tetanic spasms like those of Strychnia. (*Comptes rendus*, *No.* 25, *Dec.* 1854.)

Ergot of Rye is a Stimulant to the muscular nerves of the Uterus of the female, but to no other nerves in any marked degree. Borax and Rue possess a similar action, but are not so efficient.

When labour is retarded on account of an atony or debility of the Uterine muscle, and when also there is no obstruction or danger which can result from bringing on contraction, Ergot supplies us with a ready and effectual means of doing this. It is also efficacious in cases of uterine hemorrhage, because the open mouths of the bleeding veins in the wall of the uterus are closed by the contraction which it causes.

When given in an overdose, Ergot has a dangerous action on the brain, producing at some times narcotism, at other times syncope. But this is not the effect for which it is employed, and is altogether distinct from its operation as a Special Stimulant, which is exerted only upon the ganglionic nerves of the muscular uterus. In small doses it produces no other effect than this.

Like the other medicines of this order, Ergot is not an excitor of the heart and circulation. Its stimulant action is strictly local in its nature.

Mr. Harris, of Virginia, states that Uva Ursi has a power over the uterus which resembles that of Ergot.

NARCOTICS.

This, the second division of Neurotic medicines, is in one sense intermediate between the other two divisions, but in another sense different from both of them. Narcotics are defined to be medicines which pass from the blood to the nerves or nerve-centres; which act so as first to exalt nervous force, and then to depress it; and have also a special action on the intellectual part of the brain.

This primary exaltation of nervous force is produced by some to a very considerable extent, but by others very slightly. Of the three orders into which I have divided Narcotics, which are named from their respective actions upon the brain, Inebriants cause most, and Deliriants least, of this primary stimulation. In the second place, Narcotics depress nervous influence. This depression is not in a direct, but in an inverse ratio to the primary stimulation. The less the one, the greater the other. Thus the depression cannot be considered as the mere reaction from the stimulation, as supposed by Dr. Brown, for there would then be a direct relation between the two effects. But we find that the exhilarating action of Alcohol may often be followed by no manifest depression; and that Belladonna, which scarcely stimulates at all, exerts a very sensible depressing influence.

Regarded simply in their action on nervous force generally, the medicines of the first order of Narcotics would approach very nearly to Stimulants, and those of the third order to Sedatives. But Narcotics have all a power which is possessed by neither of the other divisions.

They influence the intellectual functions, *i. e.* the mind, and the physical ties by which mind is connected with matter. These physical ties are,—the functions of volition and sensation, by which the mind is connected with the body, moving it or feeling it; and the five senses, by which the mind, through the body, is connected with external things. These intellectual properties, the centre of which is the brain, are more or less affected by Narcotic medicines. The first action of the latter is to exalt these functions, just as they first exalt nervous force in general. The degree of this exaltation varies, as in the former case. Inebriants stimulate the mind to a considerable degree; Soporifics less; and Deliriants possess least of this primary exciting power. But it is in their secondary action on the mind that we find the most characteristic difference between them.

On referring to the arrangement, it will be seen that I have divided Narcotics into the three orders to which I have already referred by name, and which are thus designated in Latin:—

NARCOTICA.

Ord. 1. Inebriantia.
Ord. 2. Somnifera.
Ord. 3. Deliriantia.

These Orders are named from the secondary action of these different Narcotics on the intellectual functions. In the production of inebriation these functions are impaired and deranged; in sleep they are lulled or extinguished for a time; and in delirium they are excited and led astray. The several actions of these orders will be more minutely described presently, and the individual medicines of which they are composed will be shown to agree with the general definition of Narcotics.*

Dr. A. Billing considers that Stimulants call forth nervous force, and Sedatives depress it; and that Narcotics do neither the one nor the other, but merely impede its communication. I do not consider this distinction to be quite correct. Narcotics exert in the first place a stimulant, and in the second place a sedative action; but these actions have no relation in degree, for one of them always exceeds the other, as we have just seen. Thus in the whole effect, either the stimulation must exceed the depression, or the depression must be greater than the stimulation. So that in one way or the other the quality of nervous influence must be altered.

The medicines of the first order of Narcotics resemble Stimulants so far as this, that they tend altogether to increase the amount of nervous force. Perhaps Tobacco and Lobelia are exceptions to this. The medicines of the third order,

* "We must acknowledge that this arrangement is convenient, and we think that by the division of Narcotics into the three orders of inebriants, soporifics, and deliriants, we are able in a very satisfactory manner to classify such drugs as alcohol and chloroform, opium and lactucarium, belladonna and hyoscyamus."—*Dr. Maclagan's review in Monthly Journ. of Med.*, p. 447.

and some of those in the second, tend on the whole to diminish the quantity of nervous force, and are thus akin to Sedatives. A correct understanding of the differences in action which exist between the groups of Neurotic medicines is, I think, very essential to a right application of these remedies in the treatment of disease.

Narcotics, in a poisonous dose, produce coma (insensibility,) gradual suspension of the respiration, and death. Sedatives do not cause death by coma, but by syncope, or suspended action of the heart. The accumulation in the blood of Carbonic acid, itself a narcotic, may, by reason of its action on the brain, account in some part for the coma induced by Narcotic medicines. The insufficiency of the respiratory efforts is the cause of this accumulation.

Two distinct attempts, of which the second and most plausible was probably suggested by the first, have been made within the last few years to explain the operation of Narcotic medicines upon a chemical principle.

The first theory is that of Liebig. He applied it only to inebriants, such as Alcohol. He supposed that they were burnt in the system, combining with some of the oxygen which is needed by the tissues, and that by so doing they were able to check the vitality or control the functions of the latter. But it is at least a matter of doubt whether alcohol and other similar fluids are to any extent consumed in the system in this manner; and, if they were, it is not clear how they could withdraw enough oxygen to prejudice the tissues of the body, or why they should prove narcotic any more than the calorifacient articles of food, as Starch and Sugar, which themselves remove Oxygen in the same way. It has been properly urged by Dr. Snow that breathing pure oxygen does not remove intoxication or narcotism; and that the weight of Carbon and Hydrogen in twenty-four minims of Chloroform, an amount sufficient to cause insensibility in an adult, when introduced into the blood, does not exceed four grains,—a quantity quite insignificant in comparison with the oxygen absorbed by the lungs. Such simple facts are fatal to the theory of Liebig. It can only, in my opinion, apply to such agents as Sulphuretted Hydrogen gas, which, by their entry into the blood, and their obvious chemical tendency to combine *suddenly* with oxygen, may cause death by this appropriation of the vital element.

That these inebriant medicines, as well as Narcotics in general, operate by *retarding the combination of oxygen with the tissues*, by some chemico-dynamical influence, without themselves uniting with oxygen, is a proposition more difficult to gainsay.

Prout, Liebig, and Böcker have found that the amount of Carbonic acid gas exhaled by the lungs is diminished under the influence of Alcohol. Dr. Snow has proved that the same diminution results from the inhalation of Chloroform and Ether. It has been remarked by Professor Graham that the presence in the air of the vapour of Ether will retard or prevent that slow oxidation of phosphorus to which its luminous appearance is owing.

Putting together such facts as these, Dr. Snow has proceeded to deduce from them an ingenious theory of the action of Narcotic and Sedative medicines. To use his own words, he conceives "that these substances modify, and in larger quantities arrest, the animal functions, in the same way and by the same power that they modify and arrest combustion, the slow oxidation of phosphorus, and other kinds of oxidation unconnected with the living body, when they are mixed in certain quantities with the atmospheric air." He supposes that all the animal functions are essentially connected with the processes of oxidation going on in the system. (*Medical Gazette*, 1851.) Some stress is laid on the power of these substances to arrest putrefaction (a process of oxidation) in animal bodies. But, to speak now only of those volatile narcotics to which the above theory was, in the first instance, restricted, it may be urged that alcohol arrests putrefaction by coagulating albumen, and not by preventing oxidation; that if Chloroform exerts the same action, it does not do so, as might be inferred, in the ratio of its therapeutic power; and that Creosote, Alum, Sulphate of Copper, Acetic acid, and other various materials, are powerful in controlling putrefaction, but are not narcotic in any marked sense.

Again, it is urged that Cold and obstructed respiration, both of which hinder the oxidizing or calorific process in the blood, operate on the vital powers after the manner of Narcotics. But, by hindering respiration, they cause an accumulation in the blood of Carbonic acid, which is confessed by all to be itself a narcotic poison.

This discussion concerns the preliminaries only. Against the theory of Narcotic action by Disoxygenation, as maintained by Snow, Mialhe, Robert, and others, many strong objections may, I think, be urged.

1. In the first place, it may be affirmed that there is no chemical analogy between inebriants and other narcotics or sedatives. The former do not contain nitrogen; in the latter it is a frequent ingredient. Between the volatile compounds of Ethyle and Formyle, on the one hand,

and such a substance as Hydrocyanic acid on the other, there is little enough of chemical similarity; and between either of these and the alkaloids, Morphia and Aconitina, there is no resemblance at all in chemical structure or affinity. And whatever may be thought of the Alcohol series, I deny altogether that these alkaloids exert any kind of influence on the process of oxidation. But the proposers of this theory have doubtless perceived that if not extended to all narcotics, it cannot in reason be applied to any of their number.

2. I think it may further be urged that, far too much has been said of the action of such agents as Ether in hindering combustion. (It may be remarked that Alcohol hardly hinders it at all, and Chloroform itself will not prevent the oxidation of Phosphorus.) All gases and liquids which do not support combustion retard in a sort of mechanical way the combination of oxygen with other substances. They simply interpose their particles between the oxygen and the matter to be burnt. I conceive that this is the whole explanation of the action of some volatile narcotics, in retarding oxidation out of the body. When we wish to protect the proto-salts of Iron from the oxidation to which they are especially liable, we do it best by rubbing them up with sugar, which serves to protect their particles from the air. Is sugar a narcotic?

(Mialhe, who argues with much ingenuity for the disoxygenation theory, admits that the volatile oils should exert the same action as the alcohol series. But we know that few of them are narcotic, and scarce any poisonous.)

3. Narcotics and sedatives act directly upon the nerves themselves. Chloroform, Aconite, Prussic acid, and Morphia, are found by experiment to paralyze the sensory nerves when applied to them, just as Strychnia in the same way will excite the motor nerves. If, therefore, the former interfere with the blood-processes, it must be by a subsequent action of the nervous system, which is first influenced, and not by an action on the blood primarily.

4. I am inclined to think that the diminution in the amount of Carbonic acid exhaled, an observation from which the theory took its rise, may be best explained by considering the effect of Narcotics in diminishing the number of the respiratory actions. In various degrees these agents all influence the brain, and with it the centre of the respiratory function. From this interference with the action of the medulla oblongata, there follows a decrease in the number and depth of the inspirations, and in exact proportion to this decrease, will the Carbonic acid exhaled by the lungs be diminished in amount. The same thing takes place in natural sleep.

5. Among the many questions which suggest themselves, the following is foremost. If this be the explanation of Narcotic action, in what

manner do stimulants operate? Producing the reverse effect to that of a Sedative, their *modus operandi* should be exactly the opposite. They should encourage the process of oxidation. But this is an action which cannot be said to be exerted by any stimulant. And we are still further led on to the remarkable supposition that the primary stimulant effect of narcotics, such as alcohol and opium, is to be explained by their first promoting oxidation, although we have just assumed that they exert a chemical action of the contrary kind. This is very like a *reductio ad absurdum*.

6. Again, supposing this theory received, the great varieties of action observed among different Narcotics would be more inexplicable than ever. Why should these affect the motor nerves, those the sensory nerves; some the brain, chiefly, others the nerves of the heart? These things *can* only be explained by supposing a diversity of operation on the nervous system. If all these agents did nothing but keep back from its combinations the oxygen in the blood, their action might differ in degree, but not in kind—for it should always be essentially the same.

7. Without dilating upon the point, it will be enough to allude to the utter inadequacy of such a theory to account for such a wonderful and instantaneous action on the system as that of Hydrocyanic acid. It must be a very powerful anti-oxidizer, indeed.

8. In the next place it may be asked—how are the varieties of the same agent on different systems to be explained on this hypothesis? How is it that some men will bear such enormous quantities of alcoholic drinks, and the opium-eater consume in the day his two drachms or more of opium? Is it that such men have accustomed their systems to go on without oxygen? Some animals, as Apes, are said to be altogether insensible to the action of opium. But if this be a chemical action, it being granted that in the systems of all men and all animals, a perpetual process of blood-oxidation is going on,—why is it ever interrupted? Why is such an immunity enjoyed in these cases?

9. Lastly, I may again refer to the curious fact that Morphia and Chloroform act as paralyzers on the irritable tissues of plants. (v. note p. 270.) Without pretending to explain this phenomenon, we may at once perceive how strongly opposed it is to the theory now under discussion. In animals, an oxidation goes on, by which Carbonic acid is formed; in vegetables, a contrary process, a deoxidation, by which oxygen is liberated. Narcotics, it is said, act on animals by hindering the first process. How then do they operate on vegetables, where the result of their action is similar, and there is no oxidation to be retarded?

This theory is perhaps worthy of a further discussion, but I have already too largely drawn on the space at my disposal. For, as its chief defender, whose early loss we have lately had to lament, is one to whom therapeutic science is so largely indebted, I could not treat it lightly. I am not sure that I shall convince, by these objections, any of those who may already have adopted this idea. In obscure matters of this sort, there will always be found some who will prefer to construct some kind of hypothesis, however frail, on a set of ascertained facts, however few, rather than be content, like myself, to give up all dogmatic assertion, and remain still in the dark on a matter which, by its nature, is difficult, or even incomprehensible. And yet, I feel persuaded that, in this instance, at least, the latter will prove right in the end. In one sense, it is better to know too little than too much.

We are still ignorant, as we ever shall be, of the principle of life; we have not yet discovered, though some thought they had done it, the cause of nervous action; neither does it seem that we are yet in a position to make any positive statement as to the intimate manner in which Narcotic agents operate on the animal system.

Ord. I. Inebriantia.

(Alcohol; Wine; Ethers; Chloroform; Camphor; Indian Hemp; Tobacco; Lobelia.)

The medicines of this order, of which we may take Alcohol as the type, approach more nearly to Stimulants than any other Narcotics. When given in small doses, their narcotic operation may hardly be perceived. They are then exhilarants; slightly quickening the pulse, and enlivening the mental faculties. When given in large doses, this stimulating action on the heart and mental powers occurs first, and is now more intense; but it is soon succeeded by disturbance and impairment of the intellectual functions. The secondary depression of the heart is comparatively feeble, except in the case of Tobacco and Lobelia, which are exceptional members of this order.

The disturbance of the mind produced by these medicines is not of a partial, but of a general character, extending to all the intellectual functions. It is called inebriation, or drunkenness, and may exist in various degrees, The mind itself is confused and bewildered; volition is impaired, so that the man staggers in his walk; and the powers of the senses are disordered or lost. This condition, when carried to an excess, results in stupefaction, coma, and death. These are the several degrees of the same action, which is a general impairment of all the intellectual functions.

Alcohol and the Ethers produce the primary exhilaration in the greatest degree; Tobacco* and Lobelia, in the least. Though varying in degree, yet, as far as the stage of inebriation, the effects of these medicines are similar in kind.

Stupefaction constitutes the next stage of the action of Alcohol, Camphor, Indian Hemp, Ether, and Chloroform. Camphor and Indian Hemp exert at this period an anodyne influence; to which also, in the case of Indian Hemp, may be added a very curious imitation of Catalepsy. Ether and Chloroform have at this time a peculiar action in extinguishing the sense of Feeling. With this object they are commonly administered by inhalation in painful surgical operations.†

The stupefaction produced by the above medicines is not at all prominent in the case of Tobacco and Lobelia inflata. Instead of that, they both exert a particular sedative action on

* The Smoke of Tobacco contains its alkaloid Nicotia. This is a powerful poison. If it were allowed to accumulate in the blood, the act of smoking would probably be fatal. It is certainly absorbed to some extent, but it passes quickly into the urine, where it may be detected by simple chemical tests. Even the small quantity at any one time in the system will produce a very marked intoxication in some persons. It is only not a poison, because slowly taken into the system in small amounts, and eliminated *pari passu*. Dr. Paris has plausibly conjectured that Nicotia may be the "juice of cursed Hebenon" mentioned in 'Hamlet.' (*Pharmacologia, 9th edition*, p. 294.)

† The careful experiments of Dr. Snow appear to have established the fact that the volatile inebriants are powerful in inverse proportion to their solubility; also, that whether inhaled, or absorbed from the stomach, their action obeys very closely the following law: complete narcotism is established as soon as the blood has dissolved $\frac{1}{36}$th part of the quantity it is capable of holding in solution. 24 drops of Chloroform are thus equivalent to $7\frac{1}{2}$ oz. of absolute alcohol.

the heart and circulation. This is accompanied with nausea, and with great relaxation of the muscular system, like that which is produced by Antimony. It may lead to syncope and death.* But, as has already been observed, the tendency of most Narcotics is to cause death gradually, by coma and asphyxia, not suddenly by syncope, as Sedatives.

Syncope has been known to be suddenly produced in some cases of the inhalation of Ether and Chloroform. This is when the percentage of the vapour in the air inhaled is unusually large. These two medicines are also muscular relaxers, like Tobacco.

The cases which demand the employment of these medicines, as also of the other Narcotics and Sedatives, will be considered at the close of the section treating of Neurotics, and again when some of them are separately described in the fourth chapter.

Ord. II. Soporifics.

(Opium. Lactuca. Hops. Nutmegs.)

Opium, which is the chief and only important medicine of this order, may be considered as the type of Narcotics. It causes, in the first place, a slight quickening of the pulse, and some excitement of the mental faculties. It is named from its peculiar secondary action on the latter. It produces drowsiness and sleep.

We have seen that the term *intellectual function* must be understood to include not only the mind itself, but also the powers of volition and sensation, by which the mind is connected with the body,—and the five senses, by which it is enabled to appreciate the external world.

* See Sir B. Brodie's *Physiological Researches*, 1851. Also a case of poisoning by Tobacco, recorded by Dr. Skae in *Edin. Med. Journal*, Jan. 1856. Here there was first maniacal excitement, then contraction of the pupil, violent vomiting and purging, with spasms of the flexor muscles,—prostration, syncope, and death.

Inebriants affect these three in about the same ratio. Ordinarily they impair the mind, and derange the functions with which it is connected; but they do not quite extinguish either volition, sensation, or the special senses. Soporifics differ from this action in two ways. In sleep the mind may remain active; but it is left alone, dreaming, and uncontrolled by physical ties.* For the functions of volition and sensation, and the special senses of Sight, Hearing, Smell, and Taste, are entirely suspended in perfect sleep.

So that while inebriants affect similarly both the mind and the natural functions with which it is connected, Soporifics may leave the first untouched, but they entirely subdue the latter. The condition of sleep differs also in another important particular from the state of inebriation,—as well as from delirium, which we shall have presently to consider. Sleep is liable to be suddenly interrupted or suspended by comparatively slight causes, as a physical shock, or a forcible impression upon one of the senses which are held in abeyance and subjection. Neither inebriation nor delirium can be suddenly put an end to in this way.

Such appears to be the distinction between the operations of these two orders of medicines.

Pain prevents sleep, because it enforces sensation. Thus a mere Soporific, if effectual, would prove anodyne, and relieve pain.

But Opium has an important anodyne action, which is independent of its power of producing sleep, for it may occur without the latter. It is by far the best remedy for pain in the whole catalogue of medicines. It also produces relaxation of the muscular system, and is thus a powerful antispasmodic. In excessive dose it produces a marked sedative ef-

* "Sleep is the ligation of sense, but the liberty of reason.—We are somewhat more than ourselves in our sleep, and the slumber of the body seems to be but the waking of the soul."—*Religio Medici.*

fect; causing an imperceptible or irregular pulse, and very slow breathing, with contraction of the pupil of the eye. It tends to kill by apnœa; *i. e.*, by stopping the respiration.

Tobacco resembles Opium in causing contraction of the pupil, and relaxation of muscular fibre. But it is inebriant, and not soporific; and its secondary sedative action on the heart is more powerful than that of Opium. The order of Deliriants dilate the pupil. Inebriants and Deliriants act on the glands as Eliminatives, being mostly diuretic. Opium has a contrary action; it diminishes all the secretions except that of the skin, which it increases in amount. Most particularly it diminishes the secretion of the bowels, causing constipation. At the same time it impairs the appetite and digestive power, producing often nausea, and coating the tongue. It tends also to produce a determination of blood to the head.

Lettuce, from which Lactucarium is prepared, resembles Opium in its action, but is neither so powerful nor so efficient. Nutmeg and Hops have proved Soporifics when given in large doses. Dr. Herzfelder, of Vienna, has used the extract of Hops with much succcss as an anodyne, especially in inflammatory affections of the urinary organs.

The relief of pain, and the production of sleep, are about the commonest and the most grateful of the offices which fall to the lot of the physician; and in either case Opium, or one of its preparations, may be said to be indispensable. But a certain caution and care must be exercised, even in the administration of this most useful remedy. (*Vide Art. Opium*, Chap. IV.)

Ord. III. Deliriants.

(Hyoscyamus; Belladonna; Stramonium.)

These medicines are all produced by the natural order Solanaceæ. Of all Narcotics they approach the nearest to Sedatives. Their only stimulating action is to produce at the very first a slight and evanescent febrile condition,—a quick pulse and heat of skin,—which never lasts long, and is sometimes overlooked.

They are not Soporific. Their action is soon manifested by an anodyne operation, and a sedative influence on the heart and circulation. For this double action they are employed in medicine, being used in painful disorders, fevers, and inflammations. As anodynes they are not so efficacious as Opium, but their action is not followed by constipation, or by a diminution of any of the secretions.

They all dilate the pupil of the eye. Belladonna produces a peculiar dryness of the throat; and has been known to cause an erythematous eruption. Stramonium appears especially to control the respiratory nerves, and is thus used in Asthma, where there is a spasmodic circular contraction of the smaller bronchial tubes. Lobelia, a medicine of the first order, possesses a somewhat similar power. The action of the remedies of this third order of Narcotics is distinguished by the production of delirium when they are given in large doses.

Let us again assume the threefold division of the mental functions, to which allusion has already been made. Inebriants impair equally the mind, volition, and the five senses. Soporifics extinguish for awhile both volition and the senses, but may leave the mind alone. In delirium these functions are not thus impaired and held in subjection, but they are excited and led astray. The mind is occupied intently upon imaginary fancies; unreal objects and hallucinations are presented to the senses. So that Deliriants, in this peculiar phase of their action, tend to excite the mind and the volition, and to delude or derange the senses.

Speaking generally and rather inaccurately, we might say that the medicines of the first order of Narcotics bewilder and impair the powers of the mind; those of the second order subdue and extinguish them for awhile; and those of the third kind excite and derange them.

Belladonna may be used generally as an Anodyne; as an Anticonvulsive in Pertussis and other spasmodic coughs; to moderate the action of the heart; and to dilate the pupil. It has been proclaimed by Hahnemann to be a specific against Scarlatina. This theory has been supported on the slenderest grounds, but Dr. W. Begbie has taken pains to refute it. (*Brit. and For. Med. Chir. Rev.*, Jan. 1855.)

The power of Belladonna and its alkaloid over the pupil of the eye is most remarkable. Mr. B. Bell, of Edinburgh, states that $\frac{1}{8}$ grain of the extract will dilate the pupils in a child. $\frac{1}{3000}$ grain of Atropia in solution, dropped into the eye of an adult, will dilate the pupil. $\frac{1}{10}$ grain in the stomach will cause both pupils to become dilated.

There are several possible ways in which this principle, after passing into the circulation of the part, might be supposed to cause dilatation of the pupil. (1) By a direct paralyzing action on the muscle of the iris. (2) By paralyzing the nerves of the pupil generally, or that part of them only which tends to cause lessening of the aperture. To this explanation I incline. (3) By *stimulating* the nerves which supply the radiating fibres of the iris, and so enlarging the aperture.* This theory is supported by Mr. Bell and others. But as dilatation of the pupil may result simply from constitutional weakness, or from non-stimulation of the retina, (as in the dark,) it is probably the result of paralysis rather than of stimulation. The physiological experiments of Dr. Harley, interesting as they are, do not seem to me to have decided the question, which still remains in some doubt. (See various papers in *Edin. Med. Journal*, 1853–1856 inclusive.)

Hyoscyamus resembles Belladonna, but is weaker. Schroff has discovered a strong analogy between the alkaloids Hyoscyamia and Atropia. He recommends the former for dilating the pupil. It is very soluble in water, and does not cause irritation. The dose internally is from $\frac{1}{40}$ to $\frac{1}{20}$ gr. (*Wochenblatt der Z. der G. der Aerzte zu Wien*, Jun. 16, 1856.)

That the poisonous action of Stramonium strongly resembles that of Belladonna and Henbane, is proved by a case narrated in the *New York Journal of Medicine*, Nov. 1856.

Certain peculiar and exceptional effects are produced by some Narcotics when they are administered in repeated doses

* Kölliker conceives that he has established the existence of an active "dilator pupillæ" in the eye of the rabbit. (*Zeitschrift für Zoologie*, vi. 143.) And Budge believes in the existence of this muscle in man and other mammals. (*On the Motion of the Iris*, *Brunswick*, 1855.)

for a long time together. Taken in this way, Alcohol produces Delirium tremens, and great despondency of mind; as also often a chronic inflammation of the liver. The continued smoking of Tobacco is found to exert a tranquillizing influence over the mind. And the continual use of Opium or Indian Hemp, both of which are habitually consumed in large quantities in the East, produces a curious and melancholy series of mental hallucinations and disorders.

SEDATIVES.

We have now to consider the third and last division of Neurotic medicines. Sedatives are medicines which directly depress nervous force. Some affect nervous force in general; others confine their action to particular nerves. They are mostly energetic and dangerous agents. For the time being they may destroy nervous power, and remove nervous control.

They differ from Narcotics in exerting little or no effect upon the mind; and in the fact of their depressing action on the nerves being preceded by no stimulation whatever.

It might already have been concluded, from what has been said of the secondary action of Narcotics, that there are two ways in which a Sedative action on nerve may be manifested. Sedatives may destroy nervous influence; or they may simply derange it.

Let us suppose a special Sedative to derange the action of the Vagus nerve. It would probably cause the rhythmical contraction of the heart to be abnormally slow or irregular. It would be likely to diminish in the lungs the sensation of want of breath, and thus decrease the number of the respirations; and at the same time it would repress the irritability of the pulmonary mucous surface. Further, it would in some way derange the normal function of the stomach. All these things a Sedative to the Vagus nerve does actually effect.

Given in large quantity, it may cause death, by destroying those functions which in a small dose it deranges.

All the varieties in action of Sedative medicines may be accounted for by considering that they may either derange or destroy the nervous forces. In the case of each set of nerves in the body we may distinguish an action of derangement, and an action of destruction, both producible by Sedative medicines. Thus, by an action of the motor nerves of the cerebro-spinal system, convulsions or paralysis may be produced. By an influence on the nerves of sensation; pain, or anæsthesia. By an affection of the organic nerves of the heart or of the brain which controls them; palpitation, or syncope. By an action on the nerves of the lungs; cough, or apnœa. By the exertion of a sedative power over those of the stomach, nausea may result, or vomiting. These various symptoms are all brought about by Sedative medicines, but in each case the first effect is referable to a derangement, the second to a loss of nervous power. In every instance there is an impairment of natural nervous force.

Sedatives are classed among "Ganglionics" by Dr. Pereira, who conceives that they control the heart and circulation by an action on the sympathetic system of nerves. But, if they do this, there can be no doubt that they influence the brain also. The heart of an animal poisoned by Prussic acid may continue to beat for some time after the production of complete coma, and the cessation of all the other functions. Death therefore commences in an action on the brain, and the circulating system is really the last to succumb.

Narcotics act on the mind. They cause death, with stupor or delirium. Sedatives act on the organic functions of the brain, which is necessary to life, but they do not affect the mind. In poisonous doses, they kill by producing syncope, which is a suspension of the action of the heart. Hydrocyanic acid causes at the same time convulsions. These convulsions appear to be caused by a derangement of the nervous polarity of the spinal cord; and not by a stimulation of this centre, as the tonic spasm of Strychnia. (*Vide* page 279.)

Sedatives are divided into two orders, according to the extent of their action; in the same way as Stimulants have been divided.

SEDANTIA.

Ord. 1. Sedantia Generalia.
Ord. 2. Sedantia Specifica.

General Sedatives have a direct action upon all the nerves and nerve-centres in the body, the result of which is a diminution of nervous force.

Special Sedatives exert the same depressing action upon particular nerves only. Like the order of Special Stimulants, they are peculiar and exceptional agents. All those with which we are acquainted appear to direct their action to the branches of the Vagus nerve.

It is among general Sedatives that the types or representatives of this division are to be found. The definition of this order does not admit of so great a variety of action in them as must be allowed to Narcotics. A Stimulant medicine simply exalts or increases nervous force; and a Sedative simply depresses the same. But a Narcotic first does one thing and then the other; and according to the degrees of these two actions, so do some Narcotics resemble Stimulants, and others approach very nearly to Sedatives. But we have seen that Narcotics have also a peculiar and mysterious action on the mind, which action is of three separate kinds. And the same three orders, which are named according to their respective actions on the mind, are found to coincide with three stages of transition from the action of a Stimulant to that of a Sedative medicine.

It is impossible to associate in the same prescription a Stimulant and a Sedative medicine; for their actions are directly contrary, and tend to counteract one another. But it is often desirable to prescribe an Inebriant Narcotic with a Stimulant, for their actions resemble each other so much, that they are able to work together. And Deliriants, which stand at the other end of the Narcotic scale, may often advantageously be given with Sedatives, which they very much resemble in their nervous operation. Thus, on the one hand, Brandy may be given with Ammonia; on the other hand, Hyoscyamus may be prescribed with Digitalis or Hydrocyanic acid.

Ord. I. General Sedatives.

(Hydrocyanic acid. Creosote. Aconite. Conium. Urari. Colchicum. Tea and Coffee.)

These are medicines which pass into the stomach, and are capable of absorption; which are absorbed, and are proved to act after passage into the blood. From the blood they pass to the nerves and nerve-centres, and on all of them alike exert a depressing influence. Some of them are much more powerful than others. They do not exert any primary stimulant effect, or any action on the intellectual part of the brain. Most of them have special actions and tendencies.

Hydrocyanic acid is a powerful and dangerous medicine. In large doses it very rapidly takes effect, producing convulsions, syncope, and death. In small doses it is anodyne, and antispasmodic. It is considered especially to influence the reflex spinal system, and by this means may allay convulsive cough, and quiet spasmodic movement. It is very useful in Gastrodynia, and appears then to act locally upon the painful and irritable nerves of the stomach. (*v.* Prop. IV.)

Creosote stands, as a medicine, between Hydrocyanic acid and Turpentine. It has a double action; being anodyne, like the former, and a mucous stimulant, like the latter. Moreover, it is a true Astringent, which, perhaps, cannot be said of Turpentine. It is not powerful as a Sedative, but its peculiarity of action often renders it useful in Gastrodynia. It is particularly applicable when pain in the stomach is accompanied with a tendency to hemorrhage, or with a probable relaxation of the mucous coat.

Aconite is a powerful anæsthetic to the superficial sensory nerves. When applied in solution or ointment to the surface of the skin, it produces first some heat and tingling, which is attributable to a derangement of the nervous influence; and this is succeeded by perfect numbness. It is thus a most valuable topical remedy in true irritative Neuralgia. Other Sedatives and Narcotics have the same power as topical anodynes, but not in so marked a degree. In large doses Aconite is a General Sedative; producing tingling of the extremities, vomiting and syncope; and affecting the brain in various ways, as will be shown by some experiments which I have made upon its action, to be detailed in the fourth chapter. An Alkaloid called Aconitina, the most powerful of all known medicines, is the active principle of this drug.

Conium (Hemlock) also owes its properties to the alkaloid Conia. Dr. Christison has made some experiments upon the latter. He found that it produced swiftly-spreading paralysis of the motor nerves; and he considers it to act particularly as a Sedative to the reflex spinal functions. It also paralyzes the sensory nerves, but in a less degree.

More recently, Conia has been experimented on by Dr. Schroff, and found to cause giddiness, anæsthesia, paralysis, dilated pupils, and diminution of the rate of the pulse. Its action seems in many points to resemble that of Aconite.*

Hemlock is thus anodyne, a paralyzer, and produces a sedative action on the heart. It is a General Sedative. In

* *Wochenblatt der Zeitschrift der Kön. Gesellsch. der Aerzte zu Wien.* 1856.

some recorded cases of poisoning by Hemlock, coma has been mentioned as a leading symptom. But this is probably to be accounted an error of observation. Its paralyzing action on the nerves of motion is directly the reverse of the stimulating action of Strychnia; it is thus of use in cases of convulsion and spasm. It is also often prescribed as an anodyne.

Conium is further said to have a curious resolvent power over glandular enlargements, and to have thus frequently caused their absorption and disappearance. This action was first noticed and described by Dr. Fothergill. All true resolvents operate by an action in the blood, but it is difficult to conceive how such an action can be exerted by a nerve-medicine. It may possibly act indirectly by quieting the action of the heart, and controlling an irritable state of the nervous system. In the same way Opium often appears to act as a resolvent. And it is certain that Hemlock, when used for this purpose, very often fails altogether. It has been wrongfully extolled as a panacea in Phthisis; but is, in fact, of no greater use in that disorder than Hyoscyamus, Prussic acid, and other medicines which reduce the pulse. For the patient in this disease is devoured by a continual slow fever, and anything which tends to lower this fever will serve to prolong his existence.

The Urari poison of Guiana, as appears from the experiments of Brodie, and, more recently, of Kölliker, is a very powerful paralyzer of the whole system of motor nerves. It has been thus recommended as an antidote to Strychnia, and a cure for Tetanus. Its action on the heart of man is not clearly known.

Colchicum has many different actions. It has an agency in the blood, being Antiarthritic. It is an Eliminative acting on the liver and bowels. And it is also a General Sedative. To the combination of an eliminative with a sedative or anodyne action, the use of Colchicum in Gout has been, I think, erroneously ascribed. For in fact it seems to act best in this disorder when it causes no purging, and scarcely any action on the nerves. When it has been long used, it causes a great depression of the spirits, like that which may be caused by some undoubted blood-medicines, as Mercury. But it does not affect the understanding, or the special senses. In poisonous doses it depresses the circulation and the nerves generally, but it causes no stupor or insensibility. It is therefore not a Narcotic; but, like other Sedatives, it kills by syncope.

In the behaviour of the system towards Colchicum, Aconite, Digitalis, and other nerve-medicines, there are two peculiarities which are worthy of remark. They are called *cumulation* and *toleration*.

Some quantity of the medicine may often be given, in repeated doses for some time together, without any apparent result. It seems to remain in the blood, and to become accumulated or stored up there. But all on a sudden it breaks out, appearing to be discharged on the nerves, and may produce very dangerous symptoms. This *cumulative* action is especially observed by Digitalis, and therefore, considerable care is required in the exhibition of that medicine. This medicine is a Special Sedative, and will be presently considered as such. In other cases we find that the nervous system becomes by degrees inured to the effect of a particular medicine, and suffers less by its presence than it did at first. This is called *toleration*. It is particularly observed of Colchicum and of Antimony, and of all medicines which act on the Vagus nerve so as to cause vomiting.

Tea and Coffee, common articles of diet, are slightly sedative to the nervous system generally. They lower the pulse, and, by diminishing congestion of the brain, tend to clear and tranquillize the action of the mind. This activity of thought is endangered by the cerebral congestion which exists early in the morning, on account of recent sleep,—and again towards the evening, from the full meal of the middle of the day. It is thus at these times that they are found so useful, and are so universally adopted. They are, in fact, almost indispensable to the daily existence of civilized man, with whom a continual energy of mind is a necessary of life. Infusions of these substances, or of materials similar to them in medicinal nature, are adopted as a daily beverage by all civilized nations. By diminishing congestion of the brain, Tea and Coffee have not only the effect of clearing the mind, but in large quantities they induce wakefulness. This is particularly the case with Coffee. It is not clear that Tea, as commonly drunk, is ever unwholesome. Green Tea is a more powerful sedative, and resembles Coffee. Coffee has a more potent influence over the mind and nervous system than is possessed by Tea, and is apt to disagree with many persons. By diminishing the congestion of the brain which is produced by Opium, strong Coffee is of use in cases of poisoning by the latter substance.

Tea and Coffee are sometimes said to be mental exhilarants; but they only become so indirectly, by removing congestion, which is a cause of stupidity.

Both Tea and Coffee contain the alkaloid Theine (or Caffeine;) but it is probable that their Neurotic action is not so much owing to this, as to a volatile oil, which exists in both in some quantity.

They also contain Tannic acid, which is most abundant in Coffee, rendering it astringent. There is much variety of opinion and statement on the action of Tea and Coffee. It is generally admitted that they lower the pulse,—Coffee and Green Tea especially so. The latter was compared to Digitalis by Dr. Percival. (*Sigmond on Tea*, p. 120.) It has been found that the use of either of these beverages retards the waste of the tissues, and diminishes the amount of Urea and Uric acid in the urine. (*Johnston's Chemistry of Common Life*, vol. i. p. 204; and *Böcker*—quoted in *Brit. and For. Med. Review*, Oct. 1853.) But to what ingredient is this owing? Lehmann and Zobel find that the Caffeine rather increases the formation of Urea. It must then be due either to the astringent Tannic acid, or to the sedative action on the circulation exerted by the volatile oil. Böcker states that Coffee diminishes the number of the beats of the pulse and the inspirations, as well as the amount of Carbonic acid exhaled—but he denies the same action to Tea. In this he seems to be inconsistent. Dr. A. Billing has with great clearness expressed the view given above. (*Principles of Medicine*, 5th ed. p. 87.) Some foreign chemists have gone rather too far in their theories on the action of Coffee. Rochleder imagines that the Caffeine undergoes transformation into Creatine. Zobel disputes this; but he asserts, on what precise grounds I cannot say, that after being introduced into the system this principle first forms Hydrocyanic acid,—afterwards, Quinine, Ammonia, Oil of Turpentine, Urea, and Oxygen! (*Prag. Vierteljahrschrift*, b. ii. 1853.)

Ord. II. Special Sedatives.

(Antimonials. Ipecacuanha. Digitalis.)

These are medicines which, like the last, depress nervous force; yet they do not exert their influence on the nervous system as a whole, but only on certain parts of it. So far, they resemble Special Stimulants; but their effect is of a directly opposite nature. They have also no direct influence on any part of the brain.

Antimony, Ipecacuanha and Digitalis have, each of them, a number of different actions. The first has already been included among Catalytic Hæmatics, as tending to counteract in the blood the process of inflammation. But it possesses further, a Neurotic power, by which it is gifted indirectly with a more powerful control over acute inflammations than could be exerted by any slow-acting blood-medicine.* It is also Eliminative. Passing out of the body through the glands of the skin, it becomes a Diaphoretic. This may be its only action when it is given in doses too small to act upon the nerves. It must not be confounded with the diaphoresis

* The action of Antimony in slowly impoverishing the blood has been verified by the experiments of Dr. Richardson. Its action on the nerves has been referred by some to an operation in the blood of another kind. M. Millon having shown (?) that the oxidation of Iron by means of Sulphuric Acid takes place more slowly when salt of Antimony is present,—Mialhe has built upon this slender foundation a theory that Antimony affects the nerves by its power of hindering oxidation in the blood.

which accompanies the condition of nausea, and which is probably produced in another way.* Ipecacuanha is in the first place, a Neurotic of less power than Antimony; in the second place an Eliminative, increasing expectoration, as well as diaphoresis. Digitalis, too, acts first upon the nervous system; then on the kidneys, being a Diuretic.

But we are now concerned with the special Neurotic actions of this group of medicines. They all exert an influence over the three functions of respiration, circulation, and digestion. They affect the heart, lungs and stomach, parts which are supplied by the branches of the Vagus nerve, as well as by the sympathetic.† Their action is not an external action, for it is produced when they are introduced into the blood at any part. Thus Tartar Emetic, or Ipecacuanha, when injected in solution into one of the veins, will cause vomiting. M. Majendie has found that in the case of dogs they also produce pneumonia. The mere inhalation of the dust of Ipecacuanha has been found to act upon the lungs so as to cause Bronchitis. These actions as well as the various effects which are found to follow the introduction of these medicines into the stomach, can only be explained satisfactorily by supposing that they act as Sedatives‡ to the branches of the Vagus nerve, thereby deranging or destroying the natural influence of that nerve in the direction and regulation of the organs

* This is what serves so much to complicate the action of Antimony, that it seems to be useful in inflammation in a double way, as an Antiphlogistic and a special Sedative; and produces diaphoresis also in two ways, as a true Eliminative, and as a special Sedative (*i. e.* nauseant.)

† Volkmann has shown that the abdominal Vagus is chiefly made up of filaments from the sympathetic. This may perhaps account for the fact asserted by some experimenters, that the division of the Vagus in the neck does not entirely suspend the motion of the stomach.

‡ "I have heard Emetics called Stimulants; but to this I cannot consent, until I see a full dose of Ipecacuanha or Tartar Emetic make a person feel well and cheerful, and his pulse stronger, while he is sick."—*Dr. Billing: Principles of Medicine,* 5th ed. p. 86.

which it supplies. For we have already seen that the action of a Sedative medicine is of such a nature as to derange nervous force in some cases, and simply subdue it in others.*

These actions are obviously nervous actions; for they are quick, sudden, and transient, and confined to parts supplied by a particular nerve. They are exerted upon nervous forces, and not upon the blood. If then they are nervous operations, they must either be directed towards the Vagus, or to the Sympathetic nerve, for these are the only nerves which supply the parts influenced by these medicines. They cannot act upon the Sympathetic, for two reasons. If they did so, we might reasonably expect that the other parts of this nerve would be influenced at the same time. But this does not appear to be the case. And again, an action upon the Sympathetic nerve could not be suddenly and violently evidenced, for the natural action of this nerve is slow, chronic, and persistent. At all events, the effects for which they are used could not be produced by an affection of this nerve.

We may therefore conclude that the action of these medicines is exerted upon the Vagus nerve and its branches. They affect the different parts of the Vagus nerve in variable proportion.

Some apparent anomalies in their physiological influence may be explained by considering the peculiarities which attach to all sedative actions. Thus we have seen that when given in large doses to healthy persons, Hydrocyanic acid produces convulsions by deranging the reflex spinal functions; and that in convulsive affections, when the same functions are disordered, the same remedy may do good by subduing their excited condition. On similar grounds, Tartar Emetic, injected into the veins, may produce Pneumonia; and Ipecacu-

* Dr. Carpenter states that the œsophagus has been found to act in the reverse direction, even when separated from the stomach, when Tartar Emetic has been injected into the veins of an animal. (*Manual of Physiology*, p. 265.)

anha, introduced as dust into the lungs, causes Bronchitis or Asthma; and yet Tartar Emetic is advantageously employed in the cure of Pneumonia, and Ipecacuanha is a remedy for Bronchitis. When the function of the healthy nerve, or that part supplied to the lungs, is deranged to a certain degree, an inflammation of the mucous membrane or substance of the lung is a natural result. But when these tissues are already inflamed, a course of medicine, which at the same time subdues the action of the heart, and represses the irritability of the nerve supplied to the part, will be likely to effect a cure. They are both sedative actions; but the first is an action of derangement, the second one of depression. This seems to me to be the correct explanation of a difficult matter.

It was just now observed that these medicines affect the functions of the Vagus in different proportions.

The action of Ipecacuanha, when given in repeated small doses, is particularly directed to the pulmonary organs. It allays the sensation of want of breath, and diminishes the cough, of Bronchitis. In larger doses it produces first nausea, then vomiting.

Still more decided nausea is produced by Tartar Emetic. It is followed by vomiting when the dose is sufficiently large.* Nausea consists in a sensation of discomfort about the præcordial region, which is due to a derangement of the stomach, with a feeling of great languor, a cold perspiration and tremor, and at the same time a striking depression of the action of

* Both the nausea and the vomiting induced by these agents last longer than when caused by a merely irritant emetic. (See Prop. IV.) They thus impress the system more. They do not act until absorbed into the blood; and when there they remain for some time. Whereas the irritant salt, operating at once by an external action, is itself immediately rejected with the first matters vomited, and produces then no further discomfort. This was well explained by Dr. Fothergill, in his *Inaugural Dissertation on Emetics*, 1736.

the heart. This nausea may be caused without vomiting, by a regulation of the dose. On account of the depression of the heart's action, which is its chief symptom, it is often very desirable to cause nausea in acute inflammations and fevers. It is kept up by the careful administration of Tartar Emetic. It may not be so desirable to produce vomiting; for this is accompanied with great vascular excitement, and active congestion of the brain. And yet it is found that the more Antimony we can get into the blood, the more potent and durable will its antiphlogistic influence be. For this medicine appears to possess a blood-action as well as an action on nerve. Experience has shown that if the dose of Tartar Emetic be gradually increased on each repetition, it may often be tolerated by the system; that is, it does not produce vomiting; and then the remedy, being absorbed, is better able to continue its antiphlogistic and nauseating action. For the act of vomiting, besides other bad consequences, causes the rejection of that part of the Antimonial which has not been absorbed. By the operation of the Nauseant the violent action of the heart in high fever may be allayed. It is often of signal efficacy, most especially in Pneumonia.

Digitalis, given in large doses, may also act on the stomach, and cause vomiting. This operation has been ascribed,—erroneously, as I think,—to an irritating action possessed by this drug. But in smaller doses it affects the heart and circulation powerfully, without producing the other symptoms of nausea. It depresses the action of the heart. Sometimes the rapidity of the beat is slightly increased at the first, but the pulse at the same time is weaker. It soon becomes slower, and sometimes irregular. This action is characteristic of a derangement of the Vagus nerve. For it was found, in some experiments on animals made by M. Weber, that when the function of this nerve was disturbed by mechanical irritation, the rate of the heart was first accelerated, its action then became slow and irregular, and finally it stopped. There cannot be a greater mistake than an attempt to explain such a derangement by supposing this medicine to exert a primary stimulant action. Coincident with the quickening of the pulse, there is a manifest loss of power.

Digitalis is especially useful in dropsies which result from an obstruction to the cardiac circulation. By subduing the action of the heart, it relieves the congestion of the vascular system which is the cause of the effusion of serum. But it is also a Diuretic; and may thus too relieve the loaded vessels by carrying off in the urine some of the water of the blood.

Such is an outline of the action of Special Sedatives to the Vagus nerve. It is not clear whether they affect that nerve at its origin in the brain, or whether they act upon the extremities of its filaments. (*v.* page 109.)

These Sedatives do not act directly upon the brain itself. But indirectly they may affect it, when given in large doses. For by depressing the action of the heart they cut off the natural supply of blood to the brain, and may, by so doing, produce delirium and convulsions. They tend obviously to kill by syncope. Some medicines may cause syncope by an action upon the brain. General Sedatives may do so; but it does not appear that the medicines of this order ever act in this way.

Some other medicines rest very closely upon the confines of this order. Squill is the chief of these. It is not quite clear whether Squill should be regarded as a Special Sedative, or considered simply as an irritant Emetic and Eliminative. It is a valuable Expectorant. It is also a Diuretic; and from the analogy of its operation to that of Digitalis (*vide supra*,) and because it appears to be a specific Emetic, it is most probably a true Neurotic.

But we must not confound with Neurotics those medicines which exert a slow operation in the blood which results at length in a nervous affection. This may take place, to a greater or less degree, with all

Catalytic Hæmatics. Lead, which is anti-convulsive and astringent, approaches nearest of all to the recognised nerve medicines. After existing for some time in the blood, it produces local palsy, particularly of the muscles about the wrist; and sometimes affects the sensory nerves, causing sharp shooting pains in the limbs. These nervous symptoms are caused by the accumulation in the system of the poison of lead, and the deterioration of the blood which is thereby produced. In the case of the palsy, we cannot certainly say whether these causes operate first upon the motor nerves, or upon the muscles themselves.

Lead certainly has some tendency to affect the brain. All kinds of brain disorders may occur in cases of chronic lead poisoning. The metal has been found in the brain after death; but it also exists at the same time in other parts of the body. In cases of Lead-colic there is generally a paralysis of the muscular fibre of a certain portion of the intestine. The pain of the disorder is caused by an irritation of the nerves of the part.

Neurotics are medicines which tend, immediately they enter the blood, to be discharged from it upon the nervous system. They, therefore, immediately affect the latter. Hæmatics, in small doses, pass through the blood without exerting any direct effect upon the nerves. They are never discharged upon the nervous system except after they have for some time existed in the blood in such quantity as materially to vitiate its healthy character. (Corrosive poisons affect the nerves by a violent revulsive action; and are not to be considered in the same category as medicines.) Thus Lead is not a true Neurotic, but a blood-medicine. (*Vide* page 254.)

We have now concluded our brief review of the action of Neurotic medicines. Some few will be again treated of in the fourth chapter. The views of their operation which I have wished to substantiate are in many cases the same as those which are generally adopted, in some cases different from them. In either instance I have attempted to base them on observation, or on simple inductive reasoning.

It has already been observed that these nerve-medicines are more rapid and more evanescent in their action than those which preceded them. They are unable, as a general rule, to produce a permanent effect. When such a permanent impression is desired, an approach to it can be made by a continual repetition of the dose, by which a transitory action may be constantly renewed and kept up. In other cases a mere transitory action may produce a cure. This may be the case in a sudden and dangerous emergency, which will pass over if the system can be supported through it, but which threatens life while it lasts. Or, in Neuralgia, if the irritability of the sensory nerve be continually blunted by the external application of Aconite, it may at last subside altogether, and a right condition of things be restored. The same may be said of convulsive disorders, and the stimulant antispasmodics which are used to control them.

Neurotics are mostly employed in temporary emergencies. In such cases their action is often decisive and gratifying. Vital action may be restored and kept up; or excess of action allayed. Pain may be suddenly and effectually removed: delirium or convulsions subdued. Sleep may be substituted for wakefulness, or activity for torpor. By these powerful remedies we are enabled to exert an immense control over the various manifestations of nervous force; and may often, when we wish it, substitute one condition for another which is the reverse of it. When there is a deficiency of nervous force, we make use of a stimulant, or of one of the Inebriant Narcotics; when there is an excess of the same, we employ a Sedative, or one of the latter two Narcotic orders.

But when we desire to quell a long-standing and firmly-rooted disorder, which is not displayed by violent outward manifestations, but is nevertheless working fatally within, we must then call to our aid some Hæmatic medicine, which alone can be of permanent efficacy in such a case.

PROP. IX.—*That a third class of medicines, called* ASTRINGENTS, *act by passing from the blood to muscular fibre, which they excite to contraction.*

Although this class of Astringents is a small and comparatively unimportant class, yet it is necessary to separate it from all the others, because the medicines which compose it are completely distinct in their mode of operation. They do not necessarily act in the blood, although many Hæmatics are also astringent. They do not pass from the blood to the nerves. They do not always act by passing out of the body through the glands. Their operation is peculiar, but it is simple. As Neurotics act directly on nerve, so these act directly and especially on muscular fibre. They cause this to contract, whether it be striped and voluntary, or of the involuntary and unstriped kind.

Their action is more readily understood, because it can actually be seen. It takes place out of the body, or in the body—externally or internally. Nearly all astringents have the power of coagulating or precipitating albumen. By virtue of this power they are enabled to constrict many dead animal matters. They affect fibrinous tissues in a similar chemical way. But they seem to possess a further dynamical influence over living tissues, which possibly depends in some way on this chemical property. This dynamical influence is, as I have said, to cause the contraction of muscular fibre. By this all their operations can be explained. Taken into the blood in a state of solution, they pass through the walls of the capillaries to the muscular tissue. By inducing the fibre of the voluntary muscles to contract, Astringents may brace the system, and stimulate the action of Tonics. But as the contraction of voluntary muscle is short and brief, it requires for its maintenance a continual excitation; and unless the medicine is thus continually repeated, the tonic effect subsides. But Astringents further contract involuntary muscle. This contraction is slower, and more durable and important in its results. Unstriped muscular fibres exist in the middle coat of arteries, in the walls of capillary vessels, in the lining of the ducts of glands generally, and in the substance of the heart and the coats of the stomach and intestines. Astringents are irritants and poisonous in large doses. But in small doses they constrict and stimulate to a healthy condition these tubes that contain in their coats the unstriped fibre. By diminishing the calibre of the capillary vessels generally, they promote health, and counteract a lax state of the system. By the same action on the extreme vessels, they prevent hemorrhages. By constricting the ducts of the glands they diminish the secretion of those glands, because denying it an exit. By acting on the stomach and intestines, they are able to give them tone, to diminish their secretions when excessive, and thus to promote digestion.

Having premised this general view of their action, we may now proceed to prove the Proposition in which it is stated, dividing it first into four minor propositions.

m. p. 1.—That they are medicines which pass into the blood.

m. p. 2.—That they have the power of causing the contraction of muscular fibre, living or dead.

m. p. 3.—That their operation is to diminish secretion, to repress hemorrhage, and give tone to the muscular system.

m. p. 4.—That these results are to be accounted for by their action on muscular fibre, to which they pass from the blood.

These assertions are an extension of the major proposition, but their establishment is necessary to a correct understanding of the latter. Their proof is comparatively easy and simple. It is not supposed to be a certainty; but simply to amount to a strong probability, which is as much as we have a right to expect in such cases.

Astringents constitute the third class of medicines which operate on the system after being introduced into the stomach. Their action is, however, of so simple a kind, that it may be exerted on the external surface in the same way as in the interior of the body. It will be seen by a reference to the table of medicines, that the class of Astringents is there divided into two orders.

ASTRINGENTIA.

Ord. 1. Astringentia Mineralia.
Ord. 2. Astringentia Vegetabilia.

The lists of these orders are given below. With regard to the first minor proposition, it has already been proved that most of these medicines pass into the blood. The minerals included in the first order have already been noticed as Hæmatic medicines. They are all soluble in water. They are absorbed in the stomach and intestines, and pass into the blood. Many of them pass on into the secretions. The astringent parts of the vegetables of the second order are also soluble. Tannic acid is the chief of them; it is simply an Astringent; it has been found in the blood, where it changes into Gallic acid, and in that form it passes into the secretion of urine.

What then are the active properties of these medicines? They have all a certain chemical power; and a certain dynamical power. All the mineral Astringents have the power of precipitating an albuminous solution. So also do Tannic acid, Turpentine, and Creosote, coagulate albumen. Tannic acid precipitates Gelatine too. The dynamical property, which is common to all of these substances, is a power of causing the contraction of muscular fibre. It seems to depend somehow on the chemical power just mentioned; for

Astringents appear to constringe fibrinous as well as albuminous tissues by a chemical action. They also coagulate fluids and discharges which contain albumen.

When the solution of any Astringent is applied to a fresh fibre of dead muscle placed under the microscope, it is seen to contract. The power which they possess in causing the contraction of living blood-vessels may be witnessed in a similar way. The astringent solution may be applied to the web of a frog's foot, confined in an extended position. This web is traversed in all directions by minute ramifying capillaries; and these are found gradually to diminish in calibre. In the same way as the mechanical irritation of a small artery will act upon the unstriped muscular fibre contained in its coat, and thus cause the vessel to contract at one point; so it seems that an Astringent, by a chemical action on the same muscular tissue, is able to cause the capillary vessels seen under the microscope to contract and diminish in size. At all events we may conclude, both from actual experiment and from a comparison of their several operations, that Astringents are able to cause the contraction of muscular fibre.*

In the third minor proposition the chief results of their operation are stated. These have already been briefly described.

It should be borne in mind, that Astringents in large doses, and undiluted, are irritant poisons, on account of their energetic chemical action on the living tissues; that when given as medicine the dose must be properly diluted; and that their action is always evidenced first on the mucous membrane, with which they come first in contact. (See *Prop. V.*) They must pass by the blood before they can exert an influence on remote parts.

* "They act on the Solids, and corroborate them, that is, stimulate them into contraction. Being mixed in a sufficient quantity with our Liquids, they immediately coagulate them."—*Boerhaave, op. cit.* 1727.

They check secretion. They are thus prescribed when any secretion is excessive. The Tannic vegetables are given in diarrhœa; Nitrate of Silver may be administered in Pyrosis; Sulphuric acid in profuse perspirations; Uva Ursi in mucous flux from the bladder.

They repress hemorrhage. Thus Acetate of Lead is employed in hæmoptysis; Creosote and Uva Ursi are used in hemorrhage from the stomach or bladder; and the vegetable Astringents are prescribed in Dysentery.

They give tone to the system. They do this when there exists an over-relaxation of the solid fibres on account of any depressing cause, by exciting the muscles to a more or less permanent contraction, and by constringing the capillary vessels generally.

In the fourth place, it is maintained that their action in all these instances may be explained by a reference to their power in causing the contraction of muscular fibre; inasmuch as they are found to diminish the calibre of certain tubes and cavities, and these owe the contractility which they possess to the muscular fibre which is contained in their coats. It follows, then, from the rule of local access, that before they can influence these tissues they must pass directly to them from the blood.

Such appears to be the simplest and the most rational explanation of the action of Astringent medicines.

As this action appears to be quasi-chemical, we can understand how it is that dilution with the mass of the blood impairs their activity. They act best when they can immediately touch the point to be acted on; next best, when they are excreted by a gland which is to be influenced, for then the dose again undergoes concentration; least, when diluted by the whole mass of blood.

We will now consider separately the two Orders into which this class is divided.

Ord. I. Mineral Astringents.

(Sulphuric, Nitric, and Hydrochloric acids. Acetate and Diacetate of Lead; Sulphate and Sesquichloride of Iron; Alum; Sulphate of Zinc; Sulphate of Copper; Bichloride of Mercury; Nitrate of Silver.)

These medicines have already been noticed among Restorative and Catalytic Hæmatics. Their Astringent action on muscle is of much less moment than their important operations in the blood. Neither is it theoretically a matter of so much difficulty; for it appears, as we have seen, to admit of a simple explanation.

By their chemical action on albumen, these substances coagulate blood, and thus act in a simple way as styptics when applied to bleeding parts externally. They form peculiar insoluble compounds both with albumen and fibrine, and it is probably by virtue of their action on the latter that they are able to cause the contraction of muscular fibre, which is a fibrinous tissue. The constriction, set up chemically, is apparently continued and propagated by the vital force of the muscle.

Most of them, when in the concentrated form, act energetically on the mucous tissue as caustic or irritant poisons. This action hinders absorption, which is promoted by diluting the dose. The dose thus diluted coagulates albumen and mucus, and constringes the part with which it comes in contact. (*Prop. V.*)

The most important only of the mineral Astringents are mentioned above. It must not be supposed, when their chemical actions are mentioned, that such actions are always allowed free play in the living and circulating blood. They are no doubt constrained by various forces from operating there, or else the consequences of such a disturbance of the condition of the elements of the blood would be dangerous in the extreme. They act, before entry into the blood, on mucous membranes and external parts; and on coming out of the blood, on the terminal capillary vessels, on the ducts of glands, and on the mucous membranes again.

Astringents act very much alike on external parts; only that some are more soluble than others, and some excel the rest in chemical activity. But they differ considerably in their applicability for internal use. They must be given in such quantity that, after absorption and dilution by the whole mass of the blood, they may still be capable of exerting a perceptible action on distant parts. A small portion of one of them will not suffice to repress hemorrhage, or to diminish a superabundant secretion.

From this it follows that the mineral acids, Alum, and the salts of Iron, are the only medicines of this order which can in all cases be given internally with advantage. For being comparatively innocuous, they can be safely prescribed in the quantity required; whereas the other mineral astringents are poisonous substances, which cannot be given in large doses without considerable danger.

Of the mineral acids, Sulphuric acid is the best Astringent. Nitric and Hydrochloric acids are hardly to be called Astringents, at least in a practical sense. For the first undergoes rapid decomposition, yielding up its oxygen; and the other, though it first precipitates albumen, ultimately dissolves or digests it. Phosphoric acid is never used as an Astringent. We might, indeed, have supposed it to be inapplicable, from the fact that it forms soluble compounds at once with albumen and fibrine,—instead of coagulating these substances.

Sulphuric acid is a Restorative Hæmatic; and, when given in small doses, may remain in the blood, and not pass out through the glands. It acts first upon the mucous surface of the stomach. When there is a relaxation of this mucous membrane, as in many cases of atonic dyspepsia, with a large formation of flatus, and an over-secretion of the gastric fluid, this acid may be very serviceable. It tends to correct these evils by a topical action. In cases of Pyrosis, where there is an alkaline reaction in the vomited fluid, as sometimes occurs, Sulphuric acid is still more peculiarly applicable, because it further acts chemically in neutralizing this alkali. When given in larger doses, the acid cannot remain in the system, but must be excreted from it by the glands. In passing through them it tends to act as an Astringent by corrugating and diminishing in calibre their minute ducts, and thus decreases the amount of the secretion. But it does not act on all glands alike. Dr. Bence Jones has found that it seldom passes out into the urine. It therefore does not sensibly diminish the secretion of urine, and can only render it acid by displacing some other acid in the blood, and causing this other acid to be excreted. It is probably excreted partly by the skin, and partly by the bowels; for it diminishes the amount of the sweat in profuse perspiration, and of the fæces in diarrhœa. Sulphuric acid is free before entrance into the blood, and after expulsion from it into the secretions. Thus at these periods it acts as an Astringent. But while in the blood it combines with the alkali contained in that fluid, and forms a salt which is not astringent. So that when it diminishes any secretion, it is nearly tantamount to a proof that it is actually excreted by the gland which forms that secretion. It acts on mucous membranes generally, being probably excreted in small quantities by those which are remote from the stomach. It is not of use in cases of hemorrhage, except when the bleeding takes place from some mucous membrane. It is thus given with more or less advantage in Hæmatemesis, Hæmoptysis, Melæna, and chronic Dysentery,—*i. e.* in hemorrhage from the mucous surfaces of the lungs, stomach, and bowels. It diminishes excessive excretion from the bowels. It is thus often of great use in Diarrhœa, and will cure cases that have proved intractable to other remedies. It may even be of service in Cholera, especially in the early stages, when large and repeated doses, properly diluted with water, should be boldly administered.

Alum is a universal Astringent, acting more or less on all parts of the body, and diminishing all secretions. It is a very useful remedy in all cases where astringents are required. It does not seem to be impaired in power while in the blood, as is the case with Sulphuric acid; and is therefore applicable in all hemorrhagic cases. It has been highly recommended in the case of lead colic, and seems to operate in this instance by stimulating to contraction the muscular fibre of a paralyzed portion of the intestine. As a simple Astringent Alum should not be given in too large doses. For, though it coagulates albumen, an excess of Alum will redissolve the coagulum, and produce the same dissolvent effect generally as other salines.

Mialhe considers that the Alum used so largely by public singers maintains the vocal parts in a state of "flaccidity," instead of constringing them.

The astringent salts of Iron are less active in this kind of influence than the medicines already referred to. They have very little action on the glands. But in cases of hemorrhage they are particularly appropriate, for in addition to their astringent action they tend to restore the deficient red colouring matter of the blood. In many such instances the Sulphate or the Sesquichloride of Iron may be advantageously prescribed along with Sulphuric acid.

Acetate of Lead is used internally as an Astringent, but being a more dangerous remedy than the medicines above mentioned, it requires greater care in its application. It should not, if possible, be used for long together. When it has been for some time prescribed, the blue line at the edge of the gums, which is characteristic of a saturation of the system by the poison of lead, will indicate that its further administration is unadvisable. The Acetate of Lead is much esteemed as an Astringent in the case of Hæmoptysis. It is frequently combined with Opium, in spite of the chemical decomposition which follows the admixture. But it must certainly not be prescribed with alum.

The soluble salts of Silver, Zinc, and Copper, and the Bichloride of Mercury, are used with advantage as external Astringents, but can seldom be prescribed internally so as to act in this way, because they are poisonous when given in any quantity. The Sulphates of Zinc and Copper, have, however, been occasionally used in diarrhœa. And here they must not be given in large doses, not simply because poisonous, but further, for the same chemical reason as that alleged in the case of Alum.

Moreover, when applied as Astringents externally, their solutions must be very dilute, for all the mineral Astringents are caustic and corrosive, destroying texture, when in the solid state, or in strong solutions. These solutions may be applied to any part of the surface of the skin or mucous membrane, when relaxed, inflamed, or ulcerated. Their operation is simple and obvious. When one of them is applied to an inflamed eye, or to a red ulcerated sore, that is turgid with blood and discharges an unhealthy matter, it tends to promote the contraction of the dilated vessels, and thus dispels the congestion and diminishes the discharge.

Various other substances have wrongly obtained the title of Astringents, regard being had only to the result of their operation, and not to the mode in which it is produced. Thus Chalk is often of benefit in diarrhœa. It acts both by mechanically absorbing irritating fluids, and protecting the surface of the bowel, and by chemically neutralizing an acid matter by which the irritation is maintained. And when applied to the surface of inflamed ulcerated parts, it does good by absorbing the discharge, and protecting from the contact of air. Thus its action in both cases is very different from that of the true Astringents. Probably the same is the case with Nitrate of Bismuth. (*v.* p. 115.) Charcoal, which absorbs and retains fetid gases and liquids, may be of use in checking intestinal discharges which are maintained by this source of irritation.

The action of some of the minerals above named, when applied externally in the solid state, as caustics, must not be confounded with their astringent power. Its efficacy depends upon the revulsive effect which follows a local destruction of tissue. An astringent stimulates vital action; a caustic destroys it.

Ord. II. Vegetable Astringents.

(Tannic Acid. Gallic Acid. Kino; Catechu; Logwood; Oak-galls; Rhatany; Bistort; Pomegranate-rind; Rose-leaves; Uva Ursi; Tormentil. Creosote. Turpentine?)

Tannic Acid, Gallic Acid, and Creosote are the three chief Vegetable Astringents. To the first two the vegetable substances above enumerated appear to owe their efficacy. All contain Tannic Acid, or some modification of it; and Oak-galls contain also Gallic Acid.

The relative efficacy of these active principles may be summed up in a few words. Tannic and Gallic Acids may generally be used with great advantage in all cases in which Astringents are required. When applied externally, Tannic Acid is the most powerful; but for internal administration, Gallic Acid is the best. It forms an exception to the general rule that Astringents act most powerfully on the part which they touch the first. The reason of this will presently appear. Creosote, being a powerful Neurotic, cannot be employed to act on distant parts, but is appropriate in cases of hemorrhage from the surface of the stomach.

I have already said that I conceive the astringent powers of these substances to depend very much upon their chemical affinities. Tannic Acid precipitates both Albumen and Gelatine. Creosote also coagulates Albumen. But Gallic Acid does not affect either of them.

Tannic Acid does not seem to be a simple substance. When boiled with acids, or with alkalies, it yields Gallic Acid and a brown matter. Tannic and Gallic Acids yield the same set of products when submitted to destructive distillation. And it appears likely, from the researches of M. Braconnot, that Tannic is a compound acid consisting of Gallic Acid in combination with the elements of grape-sugar. Three atoms of Tannic Acid are together equivalent to six atoms of Gallic Acid and one of grape-sugar. When the solution of the former acid is heated in the air, or taken into the human system, the elements of grape-sugar are oxidized into Carbonic Acid and water, and Gallic Acid is set free. (*Vide* Chap. IV. *Art. Tannic Acid.*)

It is thus Gallic Acid which passes out into the secretions, after exerting an astringent action at distant parts of the system. And as the Tannic Acid loses weight by the decomposition, it follows that a dose of Gallic Acid produces a greater effect as a medicine than an equal amount of the other. Thus one ascertained fact is cleared up by these chemical considerations,—but other mysterious points remain still to be explained.

Gallic Acid does not precipitate albumen, and is of little use as an Astringent when applied to external parts; but it is very efficacious when given internally. Tannic Acid, which is equivalent in composition to a combination of Gallic Acid with a saccharine matter, is a valuable external Astringent. A further chemical discovery has been made, which appears to bear upon these facts. M. Pelletier has found that a mixture of a solution of Gallic Acid with one of Gum will precipitate albumen, although neither of them will affect it separately.*

Gum has the same composition as common sugar; and grape-sugar, or a material containing the same elements, is known to be continually forming in the blood. (*v.* page 139.) Thus it is likely that Gallic Acid may act along with this saccharine matter in the blood, and by this acquire chemically an astringent power, which it is not able to exert on external parts, because then isolated. But the saccharine matter is required in the system for special purposes, and thus Gallic Acid passes out into the secretions alone.

It seems probable, when Tannic Acid is given, that it is not decomposed into its constituent parts until it has to be separated from the blood by the glands.

These two compounds, and the vegetable substances that contain them, are used in diarrhœa, and in all hemorrhagic cases. As with Astringents generally, their success is not uniform. To diminish sweating,† Tannic is inferior to Sulphuric Acid; but to act as a remote Styptic, it is preferable to the other. Tannic and Gallic Acids diminish secretions generally; they are very useful in cases of hæmaturia, where Sulphuric Acid is all but useless.

Creosote is a Sedative, and cannot be well given in such large doses as to act upon distant parts. It has been used with much advantage as an injection in dysentery. Given by the mouth in cases of hæmatemesis it acts topically on the surface of the stomach in a double way, diminishing the hemorrhage by its astringent power over the vessels, and quieting the nervous irritation by which the vascular excitement is

* Turner's Chemistry, 7th edit., p. 995.

† "In the sweating of Phthisis, Gallic Acid does no good; in the Hæmoptysis, very little."—*Dr. Gairdner.*

often maintained. In cancerous cases the bleeding can never be permanently stopped.

This concludes the list of Astringent medicines.

Certain stimulant Eliminatives are employed for the purpose of checking nervous flukes, and so far stimulate the action of true Astringent medicines. Thus we administer, with more or less advantage, Aromatics in diarrhœa; Cubebs, Copaiba, and Turpentine, in gonorrhœa; and Balsam of Peru, and other oleo-resins, in catarrhal affections. These medicines may act upon and pass through the glands of the several mucous surfaces which they affect; while so doing, they may stimulate the healthy function and secretion of the gland, and cause it to displace the morbid one. Dr. Williams thinks that they first cause dilatation of the vessels of a gland, and that this is followed by contraction. There is no apparent reason why the latter effect should succeed the former. But supposing contraction to take place in this way, then these medicines would be true Astringents. But it cannot be so, for they do not diminish any of the natural secretions, but, on the contrary, increase them. Turpentine, Cubebs, and Copaiba, are Diuretics, and it is possible that while passing out in the urine they may simply stimulate the mucous surface of the inflamed urethra, and excite it to a healthy action.

These volatile oils are probably incapable of exerting a true astringent action. But it should be observed that Turpentine, when in large proportion, coagulates albumen. And on the supposition that it is really an Astringent, Turpentine has been often prescribed as a remedy for hemorrhages in different parts of the body. But it has very much disappointed the expectations that were entertained of its efficacy.

General stimulants may act indirectly as styptics to a mucous surface, when relaxed and bleeding on account of an atonic condition of the nerves by which contraction of the minute vessels is maintained.

Alcohol, in large quantity, coagulates albumen, and it may thus act as a true Astringent when applied externally.

Some Neurotic medicines diminish secretions in a way which is not well understood. The chief of these is Opium, which particularly diminishes the secretion of the bowels. Attempts have been made to explain this by an influence possessed by Morphia on the process of Endosmosis, but they are not satisfactory. It is certain that it is not a true Astringent. It is not externally styptic, and does not coagulate albumen. Some little light may perhaps be thrown upon the matter by a consideration of the other operations of Opium; but it is difficult to explain it decisively in any way.

PROP. X.—*That a fourth class of medicines, called* ELIMINATIVES, *act by passing out of the blood through the glands, which they excite to the performance of their functions.*

In this Fourth Class are included all the medicines which tend in a direct manner to increase secretion. They have received various appellations; some authors have called them special Stimulants; others, as Dr. Duncan, have named them Evacuants; while Dr. Pereira entitles them Eccritics.

The mode of operation of Eliminative medicines is a matter of considerable importance, and its consideration will require us first to make some inquiry into the character and functions of those important glandular organs which they are said to excite to action.

The rational explanation of the process of elimination or secretion has been in all ages of science a favourite topic for speculators and theorists,—sound or unsound in their views according to the light that was given to them. With regard to its essential nature, and its immediate bearing on the cure of disease, the subject has been generally understood with tolerable clearness. From the time of Hippocrates downwards, the use of Evacuants in the treatment of fevers and other disorders has been recognised, and their efficacy usually explained by supposing that they caused the passage out of the body, through the glands, of certain matters that were formed in the blood, but ought not to remain in it.

This view was more particularly insisted on towards the close of the seventeenth century by Dr. Thomas Sydenham; and again at the commencement of the eighteenth by Dr. A. Pitcairn, in an Essay on the use of Evacuants in Fevers. These both had observed that fevers and other disorders had mostly a particular tendency to pass off with an increase in one or more of the secretions; and they drew from this, and from the results of their experience, that in stimulating and urging this secretion, the physician would be doing his best to promote a cure. (*Vide* page 57.) More recently the same idea has been followed up by Cullen, Hamilton, and others.

This theory is not in our immediate province. Though based upon reasonable grounds, it has perhaps been too universally applied. It will suffice now if we assume that remedies whose action is to increase the amount of secretion have often an important bearing on the cure of disease. We have only to inquire into their manner of action. As a preliminary step, there is one general law of secretion which it is of importance that we should clearly lay down. It is this: it is the especial office of each gland, or set of glands, to secrete from the blood particular materials, and to pass them out of the body.*

It follows from this law of selective secretion, that when any morbid substance or product,—or anything which is in the system, but cannot naturally remain there,—has to pass out, it prefers to pass by some glands rather than by others. It must be remembered that the glands afford the only means by which a substance can make its exit from the blood. We are still much in the dark as to the *rationale* of this force or attraction, by which particular matters are drawn towards each gland.

Dr. Pitcairn, a great man for the age in which he lived,—a man of original thought and natural genius,—gives us, in his Essay on the Circulation of the Blood, a learned account of three theories on this matter which were in vogue at his time. They are of importance, as showing that the fact was then very clearly recognised, however dubious the explanation of

* I do not here mean to imply that the products of the actions of all glands are destined for excretion. It is probable that the bile and some other secretions are partly re-absorbed into the blood. But we are now concerned only with the function of glands as emunctories.

it might be. One party supposed that there was in each gland a certain material stored up, which prevented the passage through to itself of any substance that was not like it; just as when a sheet of paper is steeped in oil, oil only will pass through it, and not water. A second party, called the Chymical party, supposed that there must be in the immediate neighbourhood of each gland a subtle fluid or ferment, whose tendency and office it was to form and separate from the blood the materials which the gland had to secrete. A third set of physicians armed themselves with mathematics and with the newly-discovered principles of Newton, and actually worked out formulæ and equations wherewith to support their arguments. They had strong and perhaps reasonable ideas as to the definite shapes of atoms. They averred that each gland was to be compared to a sieve or strainer, having in it pores of a particular size and certain geometrical shape, and that each secreted atom could only pass through a pore that would exactly coincide in size and figure with itself.

The first two of these theories Dr. Pitcairn disputed, and treated with high disdain. The third he accepted in a modified form. He supposed that the vessels in the glands ended in small open mouths, always circular, but differing in diameter in different glands, so that each would only admit the passage of a particle whose diameter approached a certain sum. Thus he supposed that each secretion would consist only of certain peculiar particles. Possibly Dr. Pitcairn forgot that small particles would seldom hesitate to pass through large holes.

We may, perhaps, feel inclined to make light of these crude speculations of the philosophers of the eighteenth century; we may be disposed to smile at the idea of vessels with open mouths, and of glands which are riddled with holes like the buckets of the Danaides; but we must after all confess that if at the present day we have swept away these notions, we have certainly added nothing in their stead, nor can we explain this matter at all more clearly than our predecessors a century and a half ago.

The fact, however, is plain, however vainly we may try to account for it. It is an established rule, to which there are few exceptions, that each substance which is formed in the blood and has to pass out of the body, tends to pass out through some particular glands; that it is the particular function of the kidneys to excrete water, urea, uric acid, and certain salts; that it is the especial office of the bowels to excrete certain effete matters and gases; and that it is the peculiar province of the liver to excrete fatty matters, cholesterine, taurine, and choleate (or cholalate) of soda.

Water, being the necessary solvent of the solid matters in all the fluid secretions, is secreted in greater or less quantity by all the important glands. The kidneys are the chief emunctories of water,—*i. e.* they have to separate it from the blood when it has entered in an unnatural amount. But in the excretion of water there exists a compensating relation between the skin, kidneys, and bowels,—particularly between the two former. So that when water is not properly excreted by the kidneys, it may pass out by the skin, and *vice versâ*. It is well known that this change may be determined by several circumstances, particularly by the conditions of heat and cold, or moisture and dryness. The relation between the function of the skin and kidneys applies also to other fluid and solid substances, as will be seen when we consider the medicines which act upon these glands.

Now this law of selective secretion applies not only, as it seems to me, to substances which in the course of nature are formed in the blood, and have to be excreted from it, but also to other matters which have been, as it were, accidentally introduced from without, and which, being in the system, cannot properly remain there. Thus it would apply to all medicinal bodies which have passed from the stomach into the blood, and which, not being natural constituents of that fluid, must again pass out of it.

So that although it is often laid down that medicines acting on the glands do so simply by passing along in the blood, and stimulating them as they go by, I regard this as a needless complication of the subject, and a thing which is wholly without proof. In fine, I am brought to the opinion which I have laid down in the Tenth Proposition, and which I have now to establish as well as my space will permit. The affirmation may be thus divided into minor propositions:—

m. p. 1.—That Eliminatives are medicines which pass into the blood.

m. p. 2.—That they cannot remain there, but must pass out of the body.

m. p. 3.—That in so doing, they tend to pass out by some glands more than by others.

m. p. 4.—That the result of their passage through a gland is to increase its secretion.

m. p. 5.—That they are of use when the state of the system requires that the function of a gland should be restored or promoted.

What I wish to prove is, that a medicine increases secretion simply by being itself secreted; that while passing through a gland it stimulates the secreting cells, and rouses them to a proper performance of their natural function; that each eliminative medicine has a tendency towards particular glands, and increases the secretion of those glands; and thus, as far as our information on the subject extends, we find that Cathartics are excreted from the blood by the glands of the bowels, and pass out with the fæces; that Diuretics are to be discovered in the urine, Diaphoretics in the sweat, and those Expectorants which are volatile may be detected in the odour of the breath.

Any material which is naturally eliminated would act as an eliminative medicine. Thus, if a drachm of Urea be dissolved in water, and injected into the veins of a dog, it causes copious urination, which continues until the whole is excreted. Urea, in fact, is diuretic. In Rheumatism the sweat is largely increased, because an excess of lactic acid is formed in the blood. Lactic acid is a diaphoretic. These instances will illustrate the argument.

Further, we find that when an eliminative medicine is diverted from the gland by which it usually passes out, it no longer augments the secretion of that gland. Dr. Ward gives an interesting case of a woman who was never purged by Castor-oil, but in whom the oil exuded from the skin, and acted as a Diaphoretic. And it is, as I have said, well known that the conditions of cold and exercise will cause a Diaphoretic, in most cases, to act on the kidneys, because it is then excreted by them. For the same reason, warmth, confinement, and rest, will induce a Diuretic medicine to act on the skin.

Thus, if it be shown, on the one hand, that Eliminative medicines themselves pass through the glands whose secretions they augment; and, on the other hand, that when they do not pass through them, they do not, as a general rule, augment their secretion,—it may then fairly be presumed that they operate by so passing through.

I assert, then, that medicines which stimulate secretions are themselves secreted. But the converse of this,—*i. e.* that all medicines which are secreted at the same time increase secretion,—though it holds good in the main, is not invariably true. There are two chief exceptions to it. These are Astringents and Hyperæmics.

When an Astringent passes through a gland, it tends, by its natural force, to decrease secretion, and to cause constriction of the ducts. Thus Uva ursi may decrease the amount of the urine, although it sometimes does the opposite; in which case the eliminative may be said to surmount the astringent tendency. So also Catechu, Kino, and Sulphuric acid decrease the secretion of the intestinal glands. But general Astringents are not always glandular Astringents. Thus the mineral acids act as Diuretics.

By Hyperæmics I mean medicines which produce congestion. Powerful Eliminatives do this when given in excess, simply by exciting excessive action. Now it is a general rule that congestion, however caused, diminishes the secretion of a gland. Thus congestion of the Liver, produces jaundice; congestion of the kidney, ischuria. After scarlatina, when the kidneys are suddenly called upon to eliminate a morbid material from the blood, congestion of the glands may be caused, the urine is diminished, and dropsy results.

Cantharides and Turpentine are Diuretics. They increase the urine when taken in moderate doses; but when in an overdose, they diminish it, and may cause painful strangury, with an almost total suppression of the secretion. The explanation of such an action is obvious. Congestion is caused by the excessive action. In the same way we find that a large dose of Mercury, naturally a Cholagogue, may produce jaundice, by causing congestion of the liver. This fact has been observed by Dr. Graves, of Dublin. But it does not follow from this, as argued by Dr. H. Jones, that Mercury, rightly administered, does not increase the secretion of bile, and stimulate the hepatic function.

In all cases, then, in which observations have been made, we find that an Eliminative medicine is secreted by the gland which is stimulated by it, and, in most cases, that a medicine which is excreted by a gland tends to increase its particular secretion.

Having made this general statement of the case, I must attempt a more particular and detailed proof. I will treat in turn of the above minor propositions, as applicable to the following orders of Eliminative medicines:—

Class IV. Eliminantia.

Ord. 1. Sialagoga.
Ord. 2. Expectorantia.
Ord. 3. Cathartica.
Ord. 4. Cholagoga.

Ord. 5. Diaphoretica.

Ord. 6. Diuretica.

They are enumerated nearly in the order of the glands, from above downwards, in the human body. I have not enumerated Errhines, because the medicines which are used to increase the nasal mucus are merely topical irritants, and not true Eliminatives.

Of Emetics I have already spoken. Some are Neurotics, acting from the blood on the nervous system; others are local irritants. They also are not true Eliminatives.

Neither are Emmenagogues so; for the uterus is not a gland. Some of these too are Neurotics. Most of them act by causing a determination of blood towards the organ. Cathartics do this by their action on the contiguous mucous membrane of the intestines. (*Vide* page 121.)

These then are the six orders of Eliminative medicines. In the first minor proposition it is stated that they pass into the blood. This has already been in great part proved; for most Eliminative medicines belong also to one or more of the preceding classes, of which it has been shown that they pass into the blood.

Thus Antimony, Mercury, Acids, Alkalies, Sulphur, the Salts, etc., are Hæmatics primarily. The various volatile oils and resins are more or less Stimulants. So also Alcohol and Ether, as well as Camphor and others, are found among Narcotics. Colchicum, Digitalis, Creosote, and Ipecacuanha, are Sedatives. Many Eliminatives are certainly known to pass into the blood, because they are subsequently found in the secretions, as will be presently seen.

Secondly, these medicines cannot remain in the blood, but must sooner or later leave it. If they remained, they could not pass through the glandular cells. But if they pass out, they must inevitably be excreted by them.

All those medicines must be secreted which have nothing in the natural blood corresponding to them. This is the case with most Eliminatives, and with all medicines except the Restorative Hæmatics. And those Restoratives which act as Eliminatives, such as Acids and Alkalies, do so because they are introduced in so large a quantity that they cannot possibly remain in healthy blood. Thus all these medicines pass out through the glands.

Thirdly, we find that in so doing they tend to pass out by some particular glands rather than by others.

In order to show this, we may consider first the chief tendencies of the great groups of Eliminative medicines; and secondly, I shall endeavour, when considering the six orders, to show that many of the medicines included in them have actually been found in the secretions of the glands towards which they tend. The first consideration will clear the way for the second. What we have to ascertain is, that the principle of selective secretion is generally applicable to Eliminative remedies.

The most important of the substances which are used to increase secretion may be divided chemically under the following six heads, of all of which it has been proved that they are capable of absorption. (Prop. II.)

1. Insoluble mineral substances.
2. Soluble minerals,—*i. e.* Acids, Alkalies, and Salts.
3. Ammonia and volatile oils.
4. Fixed acrid oils.
5. Resins and neutral acrid principles.
6. Soluble vegetable principles.

1. *Insoluble mineral substances.*—The chief of these are Mercurials (Blue Pill and Calomel,) Iodine, and Sulphur. They are all more or less changed during the process of absorption, as they have to be reduced to a soluble condition.

They stimulate secretion generally; but Mercury particularly tends to the liver, bowels, salivary glands, and skin; Iodine to the kidneys, and to the salivary and mucous glands; Sulphur to the skin.

2. *Soluble mineral substances.*—Acids, Alkalies, and Salts may pass off by any of the fluid secretions. The chief of these secretions are the sweat, the urine, and the secretion of the bowels. The sweat is only fluid when the skin is kept covered and very warm. In other cases the choice lies between the kidneys and the bowels. The kidneys are the grand purifiers of the blood, so that most of the substances which stimulate the other glands may occasionally pass off in the urine. And soluble minerals which require some amount of water for proper solution, would tend for this reason towards the most fluid of the secretions.

But there are some other things which counterbalance this tendency. The constitution of the urine is such that it cannot safely be disturbed to a very great extent. If there be much excess in it either of acid or of alkali, a deposit is occasioned. Dr. Bence Jones found that Sulphuric acid never passed out in the urine in any quantity. We find too that when a certain quantity of Saline is administered, too great to pass off readily by the kidneys, it prefers to act on the bowels. It is more likely to be diuretic if much diluted with water; but this is not the only directing cause, for a very large quantity of a saline will prove purgative, even when freely diluted. (*Vide* Prop. II.) Thus the general rule is this: soluble minerals are in small doses Diuretic, in large quantity Purgative. This applies more especially to salts; for mineral acids act as Astringents on the bowels,—and mineral alkalies, being corrosive, cannot be given in large doses.

3. *Ammonia and volatile oils.*—The laws of endosmosis favour the passage of soluble substances through to a liquid secretion. They are dissolved and carried away on the other

side of the membrane through which they pass. In the same way it appears that volatile substances may dissolve in, and be carried away by, air. Thus they have a tendency towards the aeriform secretions. These are,—the expired air, or the secretion of the air-cells of the lungs,—and the ordinary cutaneous transpiration. While passing through the air-cells, these matters stimulate the secretion of the lining mucous membrane. They cause a morbid secretion of this surface to be replaced by a more natural one. Thus Ammonia and volatile oils are Expectorant and Diaphoretic. They may all pass out in the urine, but do not especially tend to do so, with the exception of some that are acrid, and approach to the nature of the resinous group. Turpentine, Juniper, and Copaiba, are Diuretic.

4. *Acrid fixed oils.*—Such are Castor and Croton Oils; they are Purgatives, passing off by the bowels.

5. *Resinous and neutral acrid principles.*—These are soluble in alkalies, and thus partly absorbed in the intestinal canal. Most of them are Cathartic, whether introduced into the stomach, or injected into the veins. Such are the resins of Scammony, Jalap, and Gamboge, and the principles of Colocynth and Elaterium. Some few of them are Diaphoretic, as Guaiacum and Mezereon. Some again are Diuretic, especially those which are liquid, or associated with a volatile oil, which is the case with Copaiba, Cubebs, Cantharides, and others.

6. *Vegetable principles soluble in water.*—Most of these are Diuretic; as are the Vegetable Acids, and the Alkaloids of Digitalis, Tobacco, and Colchicum. So also are the principles of Broom and Sarsaparilla. The Emetic in Ipecacuanha, and the Morphia in Opium, act on the skin. In Aloes and Senna there are soluble principles of doubtful nature, which act on the bowels.

Having thus briefly sketched out the particular tendencies in the operation of the groups of medicines which act on the glands, it remains for me to say that in very many cases these medicines have actually been proved to pass out of the body by the glands whose secretions they tend to increase. Whenever we are in a position to inquire into the facts by chemical or other means, we find that the Eliminative medicine is itself contained in the secretion which is augmented by its action, and that when the secretion upon which it usually acts is not augmented, the action has passed off by some other secretion instead. There are doubtless many cases in which no inquiry of the kind has been yet made; but additional confirmation of this rule is being continually elicited by fresh experiments, and it will be seen, when we consider separately the Eliminative orders, that all that is known on the subject is in favour of the above statement.

Assuming, then, the third and fourth minor propositions together, we conclude that Eliminative medicines, which must pass out of the blood, tend to pass out by some glands more than by others, and that the result of their passage through a gland is to increase its secretion.

They do not exert a blood-influence, nor do they act on the nervous functions; but they operate on those obscure vital forces by which secretion is directed and controlled.

The fifth minor proposition treats of the application of these agents in the treatment of disease. They are of use when it is requisite that the function of a gland should be restored or promoted. There is scarcely any disease in which some or other of them may not be of service. Their remedial applications are many and important.

Eliminatives are used to restore the functions of a gland when impaired. With this view, Cathartics are employed in constipation, Diaphoretics for dryness of skin, Cholagogues in torpid states of the liver.

They may eliminate a poison or morbid material, and thus resolve a disease. This probably is the rational explanation of the use of Diaphoretics and Diuretics in Fevers, Gout, and Rheumatism, and of Purgative medicines in a great number of disorders.

We may, by an action on one gland, be enabled to replace the function of another gland. The amount of each secretion bears more or less an inverse proportion to that of other secretions. Thus when one of them is unduly copious, we may diminish it by stimulating the formation of another. In other cases the reverse condition may occur; one of the secretions may be diminished or suppressed by a cause over which we have no control, and the matters which should be contained in it may be left in the blood, causing various mischief there. Here again by increasing one of the other secretions, we may replace the function of the diseased gland, and cause the elimination of these products from the blood by another channel.

Fourthly, Eliminative medicines may be of service by draining away from the blood fluid and solid matters. The first result of their action is to stimulate the proper secretion of a gland; but when it is pushed to a further extent, they may actually cause the excretion of some of the natural constituents of the blood. Thus by an action on the skin or the kidneys, we may cause a copious evacuation of water, holding in solution saline matters. By increasing the secretion of the intestinal glands, we may drain away the serum of the blood, in an altered form, into the cavity of the bowels. Thus it is that all Eliminatives are more or less antiphlogistic. Cathartics are especially so. Their influence, when carried to excess, is analogous to that of blood-letting. As evacuants, Cathartics are employed in diseases of the brain especially; and Diuretics are made use of in dropsies to diminish the amount of fluid in the blood, and in this way to promote absorption.

So much having been said of the general action of Eliminatives, we proceed to make a few remarks on the individual orders of medicines which are included in this division. Those substances can alone be properly included in these groups, which really act on the principle of elimination, as above defined. There are in many instances other medicines which are found to increase secretion in an indirect way.

ORD. I. SIALAGOGUES.*

This name is applied to medicines which in various ways increase the quantity or promote the excretion of the saliva. The saliva is a slightly alkaline, viscid fluid, containing about one per cent. of solids. These consist of mucus-cells, alkaline salts, a minute quantity of albumen, and of a substance called *Ptyaline*, which has the power of converting Starch into Sugar. (Bernard.) Sialagogues are seldom employed as remedial agents; for the excretion of saliva is constant, and very rarely suppressed, and it is so small in quantity, and so great a source of inconvenience when increased to any amount, that Sialagogues can never be employed as general evacuants. There are two kinds of Sialagogues.

Any solid substance which excites the mucous surface of the mouth, as the natural food,—or even the act of mastication alone, will suffice to bring on the secretion of saliva. An irritant substance, as Ginger, or Pyrethrum, tends especially to cause this secretion when masticated. Catechu and Betel-leaf are chewed for this purpose by the natives of the East.

Such a stimulation of the salivary glands may be advantageously resorted to on the counter-irritant principle in obstinate cases of head-ache, ear-ache, or tooth-ache, or in neuralgic or chronic rheumatic affections of the face.

When the quantity of the saliva is thus increased, it should

* No lists of the Eliminative orders will be given; for as only a general outline of the mode of action of these medicines is intended, a detailed enumeration of the remedies comprised in each order would involve a needless appropriation of space.

not be rejected, but always swallowed when possible; for this secretion is apparently useful in the stomach, and essential to the proper carrying on of the digestive process. (By means of the Ptyaline in the saliva and the pancreatic fluid the starch of the food undergoes the necessary transformation into glucose.) The chewing of Tobacco, Betel, and other substances, is frequently found useful by sailors on long voyages, and is adopted as a preservative against the dysentery and diarrhœa with which they are so often affected. This advantage is to be attributed to the increase in the salivary secretion. On the other hand, we find that the practice of constant spitting is productive of very injurious effects; and it is more than possible that the pale faces, lank figures, and dyspeptic maladies, which are so common among the American people, may be due in part to the prevalence of this habit among them.

These topical irritants and masticatories are not true Eliminatives. There are also some medicines which by another topical action may occasionally produce salivation. These are Sedatives. Hydrocyanic acid, Tobacco-smoke, Digitalis, and nauseant medicines, may act locally so as to paralyze the muscular fibres by which the constriction of the salivary ducts is maintained, and thus allow the secretion to pour out uncontrolled into the cavity of the mouth.

True or Eliminant Sialagogues.—These are medicines which are actually excreted from the blood by the salivary glands, and which increase their natural secretion while passing through them. Mercury is the most important of these. When given to a considerable extent, it causes soreness and redness of the gums, and profuse salivation. It probably increases the amount of saliva even before this soreness is produced. It is not given for the purpose of producing salivation.*

* These medicines never cure diseases by *salivation*, as many think. It is not *salivation* that cures the *Venereal Disease*, but *salivation* follows, because the disease begins to be cured."—*Boerhaave.*

but in cases where the full action of Mercury is desired this symptom is made use of as a sign that the medicine has taken full effect upon the system. Not only is the amount of the saliva increased, but a quantity of albuminous material and of fetid products is added to it. If we permit this action to be carried to too great an extent, sloughing of the gums and other dangerous results may be produced.

In some rare cases salivation has followed the administration of Iodine. It is also not an unfrequent symptom of chronic poisoning by Lead. In cases of salivation by these Eliminative medicines, the substance which has caused the increased secretion may be, and has been, discovered in the saliva by chemical tests. They are therefore true Sialagogues.

Lehmann finds that if Iodide of Potassium be taken (in the form of a pill) in a moderate or large dose, Iodine may be detected in the saliva in the course of ten minutes. And in mercurial salivation, he has invariably detected the mercury in the secretion of the salivary glands, both by the galvanic test, and by dry distillation of the residue of the saliva. (*Physiological Chemistry*, vol. ii. *Art.* Saliva.)

The Pancreas secretes a fluid which resembles the Saliva, and probably much more of this than the salivary glands. True Sialagogues probably act on the Pancreas also, and may thus assist in the digestion both of starchy and fatty matters. When the Pancreas is diseased, and digestion suffers from it, Sialagogues may still do good by causing an extra formation of Saliva, which may in some part supply the place of the pancreatic fluid.

Ord. II. Expectorants.

This term, when taken in its widest sense, is applied to all medicines that cause the evacuation of mucus from the secreting surface of the respiratory tubes and cavities. They help the natural process of Expectoration.

Many medicines are capable of acting indirectly as Expectorants. Anything which causes cough, as an irritant gas, will do it. So will anything that thins the mucus when thick and viscid,—*e. g.* the inspiration of the vapour of hot water. Special Sedatives, which control the function of the Vagus nerve are particularly notable as indirect Expectorants. Such are Antimony and Ipecacuanha. By diminishing the morbid irritability of the pulmonary surface, they prevent the continued secretion of mucus. By allaying a spasm of the small bronchial tubes, and controlling the nervous sensation of want of breath, they may promote the evacuation of that which is already secreted.

Opium and Stramonium, classed among Narcotics, depress the function of this nerve as well as the nervous forces generally. So do other medicines similar to them. Opium in small doses allays irritability and diminishes spasm, and is then an indirect Expectorant; but in large doses it acts so powerfully as to render respiration difficult and expectoration impossible. Its use therefore demands great caution.

True Expectorants.—The action of Antimony and Ipecacuanha upon the secretion of bronchial mucus is of so specific a character as to render it highly probable that these medicines add to their neurotic influence a true eliminative agency. We are as yet unable to decide whether or not they are ever secreted by these mucous glands, because not only is the analysis of the mucus a matter of difficulty, but hitherto no investigation of the matter has been made. Squill also is probably an Eliminative Expectorant.

Many of the true Expectorants are volatile and odorous in nature. All excreted substances have to pass by an endosmotic process through a thin animal membrane. And it is necessary, before they can pass, that there should be on the other side of this membrane something which is capable of dissolving them. Diuretics are soluble in water, and they pass through into a watery fluid. But these Expectorants, whether they pass through the mucous glands, or immediately through the thin wall of the lung-cell, are brought directly into contact with air. And in this air these volatile matters are soluble, and are carried away by it.

This appears to be the reason why the Eliminatives which are volatile in nature tend particularly to act on the two aeriform secretions,—*i. e.* on that of the air-cells of the lungs, and on the common cutaneous transpiration. For though the glands of the mucous membrane of the lungs secrete mucus, yet the chief object of the terminal portion of that membrane is to absorb and secrete the gaseous matters of the blood. The following are the chief volatile Expectorants, the odours of which have been clearly detected in the breath of persons to whom they have been administered:—Ammonia, Turpentine, Camphor, Alcohol, Ether, and the volatile oils of Onions, Fennel, Asafœtida, Carraway, Cinnamon, and Anise.*

These medicines, and others like them, are thus excreted by the air-cells, or mucous glands of the pulmonary surface, and while thus passing through they stimulate the latter to a right performance of their function. When, as in the case of Bronchitis, the secretion of mucus is increased in amount, or deteriorated into a purulent matter, they may be of service by causing the healthy secretion to replace the diseased one.

Expectorants are very uncertain agents. The reason of this is, that the pulmonary glands are not naturally intended to act as emunctories, or dischargers of morbid matters from the blood, and thus are less prone to be excited by Eliminative medicines than other glands whose proper office is one of

* The function of the pulmonary membrane (as of the skin) is absorption as well as excretion. Under certain circumstances some of the above mentioned substances may be thus absorbed. Ammonia, excreted frequently in the breath, undergoes rapid absorption when inhaled. The breathing of an atmosphere impregnated with the vapour of Turpentine may cause the urine to acquire the characteristic odour of violets. To this absorption of Terebinthinate vapour many of the maladies to which house-painters and others are liable (commonly attributed indiscriminately to Lead) are to be ascribed.

general elimination. And yet we find that the effete gases which should be excreted by the bowels are sometimes voided by the lungs in cases of aggravated dyspepsia, causing tainted breath. Just so may other adventitious elements of the blood, as these volatile medicines, be sometimes excreted by the pulmonary membrane. But they may often pass off by the skin or by the urine, and would not then act upon the lungs at all.

For the same reason that the lungs are not general emunctories, and cannot be made use of to produce a wholesale evacuation from the blood, Expectorants are of no use as general Antiphlogistics. In this they differ from the four remaining groups of Eliminatives.

They are only employed in pulmonary disorders, where we desire to influence the amount or character of the mucous secretion, when the mucous membrane is inflamed or irritated. In old and chronic cases of Bronchitis the stimulant volatile Expectorants are the most applicable. Tartar Emetic and Ipecacuanha are appropriate in acute and inflammatory cases, because they exert a nauseating and depressing action. They are sometimes given in sufficient doses to act as Emetics; for the act of vomiting mechanically assists the expulsion of mucus from the air-cells and passages, by causing straining and compressing of the lungs.

Ord. III. Cathartics.

Cathartics are medicines which tend to increase the secretion from the inner surface of the bowels, and promote the natural expulsion of the contents of the intestinal tube. Of these two operations the first only is an action of elimination, and the second is an accompaniment to it. The first can hardly take place without being followed by the second; but in some few cases the second action alone may be produced.

The subject of the application of Purgative medicines is so extensive, that it is impossible for us now to inquire into it at any great length. It should however be observed, that they are the most powerful and the most useful of all Eliminative medicines. The fæces consist partly of the undigested matters of the food, and partly of a secretion which is poured out of the inner surface of the bowels.* (*Vide infra.*) The majority of Cathartics increase the secretion. Whatever notion we may adopt as to its physiological purpose, it appears that we can act upon this intestinal function with ease and certainty in the great majority of cases. The surface of the intestine, covered as it is with a closely-packed glandular apparatus, forms in the aggregate the largest secreting organ in the body. From the measurements made by Meckel, it appears that it covers a space of 1400 square inches. By the administration of a medicine of the present group, we are enabled to act upon this surface, producing simply an increase of the fæcal secretion, or causing, when the action is violent, an outpouring even of the fluid part of the blood (in an altered state.) When this secretion is stopped, we may cause it to reappear; when another secretion is repressed, we may be enabled to replace it by this; and in the treatment of plethoric or inflammatory disorders, we find among Cathartics the simplest and readiest of antiphlogistic or evacuant medicines. For they possess these great advantages,—that they act with certainty, and produce a notable effect.

All medicines which by a mere external action augment the secretion of the bowels, or promote its evacuation, must be regarded as *indirect* Cathartics, for they do not operate on the eliminative principle. An outward irritation of the mucous membrane is sufficient to excite the peristaltic con-

* According to Berzelius, Marcet, and others, this secretion contains mucus, salts, albuminous matters in a state of change, or undergoing decomposition, and a crystalline material called Excretine, the analogue of Urea in the urine.

traction of the bowel, and may even increase the secretion of that mucous surface by a reflex nervous action, in the same way that an irritation of the mucous lining of the mouth will cause the secretion of saliva. All substances which, after being taken into the stomach, are not absorbed, which are thus pushed onwards along the inner coat of the intestine, and by their mere accumulation excite its muscular contraction, must operate more or less as indirect purgatives. Of such a nature are the ligneous fibres of vegetables,—the bulky pulp of fruits, as in Prunes, Tamarinds, and Cassia,—and the husk of wheat in brown bread,—all of which are known to act as laxatives. Very different from these in the intensity of their action are the resinous Cathartics, as Scammony and Gamboge, which, though capable of absorption, appear also to act in some cases by an external irritation of the intestinal surface. They are also true Eliminatives, for they are known to become absorbed; they may thus act in a double way, both directly and indirectly. (*Vide* p. 112.) In small doses it is probable that they are simply Eliminatives, but when given in large doses they may add to that an irritant external action, and produce a very powerful or even dangerous effect.*

True Cathartics.—These are very many in number. At whatever part of the system they are introduced, their action is the same. If one of them be injected in solution into the veins, or absorbed from the surface of the skin, it passes at length to the intestinal canal, is excreted by the glands of the mucous surface, and causes purging by augmenting their natural secretion. When given as a medicine, the Cathartic is first received into the stomach. It is capable of absorption,—whether it be soluble in water, or in acid, or be of an oily or

* "Some *Purges* act only by *irritating* the *Fibres*, or muscular parts of the intestines, and *others* do not *act* till they enter the blood-vessels, and are mixed with the *mass* of the blood."—*Boerhaave*, 1727. This correct view of the case was subsequently forgotten or disregarded.

resinous nature,—as was ascertained in the consideration of Proposition II. It is absorbed; and passes along in the circulation. But it is unnatural to the blood, and cannot remain in it; so that it is at length expelled by the eliminative force at the lower part of the intestinal canal, at a part which is more active in excretion than in absorption, though not very remote from the absorbent surface at which the remedy first entered. It is a common but erroneous notion, that Cathartics do good simply by removing irritating matters from the intestines. In most cases they also purge the blood. This action of Cathartics by absorption and subsequent secretion is illustrated by the experiments which I have made on the operation of Sulphate of Magnesia—to be detailed in Chapter IV. We have many proofs of the fact that Cathartics will act from the blood as well as from the bowels. Solutions of Jalap, Gamboge, Rhubarb, and other such substances, will produce purging if introduced into the blood at any part. Similarly, the fine dust diffused in the air from Hellebore or Colocynth while pounded, has been absorbed by the pulmonic membrane, and caused purging.* And Aubert finds that a solution of Sulphate of Magnesia, when injected into the veins of an animal, acts on the bowels.†

Cathartics may be advantageously divided into three groups:

* R. Bayle, Treatise of *Effluviums*, p. 62.

† "The medicines of this class are those which *dissolve* the Blood into a *serous* liquid, and *move* it more quickly when so *dissolved*, that it may be applied in greater plenty to the Intestinal glands. To effect *both* these, it is necessary that the Medicine should be *mixed* with the mass of blood."—*Boerhaave*, 1727, *op. cit.* p. 218. Thus the theory of elimination, as applied to Cathartics is by no means a new one. Tournefort, in his Materia Medica (1708,) makes a similar statement. "The thinner part of the Catharticle Tincture makes its way through the Chyliferous ducts, and so passes into the blood, where it causes a new fermentation, by which means the foreign and extraneous parts of the blood, not much unlike the scum or froth of boiling liquors, are by degrees separated from the rest, and are discharged through the passages of the intestinal glands."

—1. Mercurials, which tend to increase all secretions; 2. Some resins, oils and acrid principles, which tend especially to the bowels; and 3. Salines, when given in such amount that they cannot pass off by the kidneys.

Mercurials, being also Cholagogues, are especially useful in bilious habits. When given to act on the bowels, a Mercurial is generally conjoined with another purgative, that it may not do damage in the system by remaining in the blood.

In the second group the great majority of Cathartics are included. They vary very much in the intensity of their action. Some are mild, and may be administered in inflammations and fevers, or even in pregnancy, where a gentle action is required; others are powerful and drastic, and may cause serious congestion, or even inflammation of the bowel. All the resins and acrid principles are more or less heating, and should be administered very carefully in febrile states of the system. Of the resins, Jalap is comparatively mild, and may be given to children without risk; while Scammony, Colocynth, and Gamboge, are more drastic. Of the oils, Olive-oil is merely laxative; Castor oil may be given in all cases without danger; but Croton-oil is a dangerous hydragogue Cathartic. Of the medicines which owe their efficacy to acrid principles, there are some which are mild in operation, and whose principles are soluble in water. Such are Rhubarb, Aloes, and Senna.* Senna is somewhat irritant. Aloes appear to act on the lower part of the intestine, and is therefore objectionable in cases of pregnancy or of uterine disorder. Hellebore is a more powerful acrid, but is now seldom used. Elaterium is the most potent purgative known.

* It is probably to their peculiar resinous constituents that the purgative power of Aloes and Senna is owing, and not to their crystalline principles, Aloine and the so-called Cathartine, which are bitter tonics. Robiquet found that Aloine did not cause purging.—(*Journ. de Pharmacie, Avril*, 1856.) The same has been discovered of the Cathartine of Senna.

In cases of dropsy, when all other medicines have failed, one-twelfth of a grain of this substance has been known to produce a copious evacuation.

Salines, *i. e.* salts of the alkaline and earthy metals, are all more or less purgative when given under certain conditions. Under other circumstances they may pass off from the body by the kidneys or the glands of the skin. The circumstances which determine the excretion of saline matters appear to be simple in nature. In the common condition of the body it is not possible for the secretion of the skin to be very largely increased, or rendered fluid. Suppose then a soluble saline, as the Sulphate of Soda or Magnesia, or Tartarized Soda, to have obtained entry into the blood, it has the choice of being excreted by the kidneys or the bowels. The alternative appears to depend mainly upon the amount of the dose. A small quantity may pass in the urine, and will not produce purging. But a large quantity cannot so pass; it is excreted by the glands of the bowels, and acts as a Purgative. It has been supposed by some that a saline solution proves Purgative or Diuretic according to the degree of its dilution only. This matter we have already considered at some length; and the reasons which have induced me to arrive at a contrary conclusion have been detailed under the head of Proposition II. (See also Chap. IV., *Art.* Sulphate of Magnesia.)

Magnesia and its Carbonates are to be grouped along with saline purgatives. They combine with the acid of the stomach to form soluble Lactates, which are then absorbed.

Salines are hydragogue. Requiring water for their proper solution, and having further a great affinity for it, they convey a large quantity of the aqueous part of the blood with them through the glands of the bowels. When their action is very powerful, some of the albumen of the blood, in an altered state, may be purged away along with this. (It is the form of Albumen which Mialhe has named *Albuminose*, which is precipitated by Tannin, but not by heat or mineral acids.) This may also take place with the drastic resinous Cathartics. But the latter are much more violent in their action, producing a degree of griping and irritation which is dangerous in febrile cases. Salines, on the contrary, are cooling, and mild in their operation. They are appropriate in inflammations, not only for this reason, but because, while passing through the blood, they exert in it, as we have already seen, a mild action of an antiphlogistic nature. (*Vide* page 217.)

When the vegetable salts of the alkalies are given in diuretic doses, they are decomposed into carbonates while in the system. This does not appear to be the case when they are given in such quantity as to pass off quickly by the bowels.

These various Cathartic medicines are affirmed to act on the eliminative principle: it follows then that they must themselves pass out of the body along with the secretion which is augmented by their action. It is natural that the fæces should have been less examined than other secretions. The resins of Jalap, Scammony, and other such substances, are affirmed to pass out along with them. From Rhubarb and Gamboge they derive a light-yellow colour. Of the passage of saline Purgatives we have long had an indirect proof; which is, that after their administration the amount of saline matter in the urine is not materially increased. But lately Buchheim has discovered the sulphates of soda and magnesia in the fæces, after purging has been produced by their administration. Castor-oil is seen in the evacuations, sometimes little altered, at other times in the form of a solid fatty substance. M. Lehmann has detected Mercury in the fæces, whenever it was given as a Purgative, and whatever the colour of the evacuation. Herrmann and Merklein have done the same. (See *Lehmann's Physiolog. Chemistry*, vol. ii.) When combined with a sufficient amount of Opium, it neither acts as a Purgative, nor does it pass out by the bowels; and it has therefore in that case a better opportunity of exerting its operation in the blood. Buchheim, too, has prevented the action of saline purgatives by hindering their excretion by means of a dose of Morphia or Tannic acid. We always find that when a Cathartic passes off in some other way than by the glands of the bowels, it fails to produce purging. Thus a copious dilution with water may sometimes cause it to be excreted by the kidneys, which are the natural emunctories of water. In some persons that are wont to perspire very freely it is difficult to produce purging. The case related by Dr. Ward, of a woman with whom a dose of Castor-oil was seen to pass off by the skin, and invariably failed to act on the bowels, is an extreme instance of this kind.

Of what use and intention, we may now venture to ask, is this intestinal function, the continual maintenance of which in a healthy condition is found to be so essential?

It was some time ago supposed by many that the fæces consisted simply of those parts of the food which remained unabsorbed, and that all Purgative medicines alike acted by exciting the peristaltic motion of the bowels, and causing thus the ejection of these undigested matters. Such an opinion is now rarely maintained. Although very little is known of the separate functions of the glands of the intestinal mucous membrane, yet it is generally supposed that the fæcal matters consist in great part of excrementitious substances which are separated by their means from the blood. The excretion of fæces continues when no food is taken. It is known to go on with starving men, and with patients in fever. Liebig argues for the secretion of the greater part of the fæces, on the ground that they contain nitrogenous matters, whereas all the nitrogenous parts of the food should be absorbed for the purposes of nutrition. Thus these are probably the excreted products of changes in the system, which it is the province of the bowels to separate from the blood. (*Anim. Chem.*, p. 160.) The odour of these matters is partly owing to sulphuretted hydrogen, or hydrosulphate of ammonia, both of which are the products of animal decomposition. On account of their presence a black colour is communicated to the fæces by the internal administration of the salts of iron.

It seems to me to be probable that the constituents of the living as well as of the dead body are constantly subjected to the control of chemical laws, and undergoing destruction and change. Some products of these changes in an early stage are eliminated in the urine; but in great part they go on to actual putrefaction. The results of this, which are of an offensive character, are apparently discharged from the body through the follicles and glands of the intestines. We find that this decomposition is promoted and accelerated by heat, in the same way as with dead animal matter. For this reason it appears that the natives of warm climates excrete a much larger quantity of fæces than the dwellers in colder latitudes; and they are also more subject to Dysentery, Diarrhœa, and Cholera, on account of the extra work thrown upon their intestines. A similar explanation may perhaps be assigned to a curious fact noticed some time ago by Mr. Curling—viz. that acute ulceration of the duodenum is a frequent consequence of severe superficial burns. A quantity of gangrenous or decomposing matter may in such a case be carried from the surface into the circulation.

This blood-decomposition, which I suppose to be always going on, may be accelerated by the action of certain morbid poisons or processes. The secretion of the bowels is then increased, and by the excitement or over-work a diseased condition of the intestinal surface may be established. In this way the diarrhœa and ulceration of the glands in Typhoid fever may be accounted for. The air of a dissecting-room, the use of water contaminated with decomposing organic matter, or the neighbourhood of a noxious sewer, is apt to bring on diarrhœa by exciting a putrefaction of the blood.* Severe bodily exercise, as a long walk, may cause it, by increasing the waste of tissue. We find that constipation is commonest in youth, when nutrition is most active; and diarrhœa most frequent in old age, when waste and decay go on the fastest.

When these decomposed matters, which should be excreted, are retained in the blood, as is the case in constipation, they affect very injuriously both the brain and the system in general, causing torpidity of the one, and in the other favouring the progress and development of every description of morbid action. It is by clearing such matters out of the blood, as well as by their antiphlogistic or evacuant action, that Cathartics become useful in so many diseases, and particularly in disorders of the brain. It would seem that the substances which should be eliminated by the bowels have, when retained in the blood, a peculiar action in the aggravation of disorders of this latter organ. Thus from very early times the exhibition of drastic purgatives, particularly Hellebore, has been strongly recommended in cases of mania.

But there is scarcely any disorder in which there is not, in some way or another, a deranged condition of the intestinal function, and in which therefore the judicious employment of purgative medicines is not at some time necessary.† Either there is constipation, in which case there is a danger of the fæcal matters being retained in the blood; or there is diarrhœa, which is probably due to an over-formation of these materials

* See "*Pereira on Food and Diet*," pp. 89, 90.—M. Gaspard injected a quantity of liquid, in which vegetable matter had been decomposing, into the jugular vein of a dog. Soon after there were copious evacuations from the intestines of a highly fetid matter, mingled with blood. It has often been noticed that rotten eggs and putrid articles of food will cause purging in men. (*v.* Boerhaave, *op. cit.* p. 187–8.)

† "If our system of medicine were reduced to the blind employment of one single mode of treatment for all diseases, and we were left to choose between

in the system, and an attempt of nature at their evacuation. In each of these cases Cathartics may be necessary. The first condition is the more obstinate of the two; the second the more immediately dangerous. Some general indications for their treatment may be here alluded to.

In the treatment of constipated habits it is better to keep up a constant and gentle action on the bowels than to give violent doses occasionally. A condition of this sort may sometimes coexist with comparative health, and may then often be remedied by a slight alteration in diet, and the prescription of such kinds of food as are more relaxing in their nature than those hitherto taken. Dr. Hamilton, in his work on Purgative Medicines, states that when they are given in constipation, he has found that they become more and more powerful, and may be taken in smaller and smaller doses the longer they are continued. This is probably the case with such as Castor-oil, Scammony, and Jalap, which are simply cathartic in their action. But others, such as Rhubarb and Aloes, contain a bitter and astringent matter along with the purgative principle, and, though they first act upon the bowels, tend for this reason in the second place to confine them. Thus while the former are best in cases of constipation, the latter are preferable in diarrhœa, as they supply us then with the very action which we require.

There are two ways, apparently opposite and inconsistent, of treating a flux from the bowels. We may try to encourage it, by Purgatives; or attempt to suppress it, by Astrin-

bleeding and purging, the indiscriminate adoption of the latter would be a far less evil than that of the former."—*Requin.*

"The gastric method of treating disease, which consists in purifying the intestinal canal and the abdominal system, has been a fundamental method of practice from the earliest times. It has lived through all the vicissitudes of ages and theories, and it may be truly said that the intestinal canal is in the great majority of cases the battle-field where the issue of the most important disorders is decided."—*Hufeland.*

gents. Thus we may treat a common diarrhœa by Castor-oil, or by Sulphuric Acid. In dysentery we may give Calomel, or Catechu. Even in Cholera some recommend Opium, while others have employed Castor-oil, and Croton-oil. In the most obvious case, *i. e.* in simple diarrhœa, it is apparent that both plans are appropriate, but at different periods of the disorder. The symptom depends upon the fact of something being formed in the blood which ought to be excreted from it. Probably it is an excess of that material which is ordinarily excreted by the bowels. Its passage out by a natural effort causes at first a simple increase of the usual evacuation. It is at this time that we should give a Purgative, to favour the natural excretion, and thus, if possible, to put an end to the disturbance. But sometimes it fails to do so. The matters to be excreted are irritating, and such an excitement may be caused in the glands by their passage out, that even after this necessary secretion an inordinate and unnatural flux may be maintained. When the symptom is thus inveterate, and refuses to yield to a brisk Cathartic, it is advisable to resort to Astringents, in order to put a speedy stop to the too copious secretion. To do this in the first instance would have been wrong, except in special instances,—as in the diarrhœa which is the forerunner of cholera, when Astringents (as Sulphuric acid) should be used from the first.*

Catharsis is in a manner complementary to the other secretions, especially of sweat and urine. It supplies their place when deficient, and is lessened when they are in excess. Excessive sweating will render an action on the bowels less easy. When constitutional, the intestinal flux may be promoted by the use of cold baths. A cathartic diminishes sweating; a

* In a case of Diarrhœa in which the dejections were examined by Braconnot, a considerable amount of carbonates and acetates of the fixed alkalies was present. In such a case an acid would obviously be of service in neutralizing a tendency to alkalinity. (*Journ. de Chimie Méd.*, Dec. 1854.)

diaphoretic often counteracts catharsis. The same is the case with the urine. When this is deficient, as in Bright's disease, a diarrhœa comes on, as the effort of nature towards a cure. By the employment of purgatives we can best stave off the dropsy, which in this case is to be apprehended. Dr. Richardson relates, in the 'Philosophical Transactions,' (vol. xxviii. p. 167,) a remarkable case of a boy who lived to seventeen years of age without any secretion of urine, the deficiency being supplied by a constant diarrhœa.

In some febrile and plethoric cases it is difficult to obtain the full action of a Purgative. This is because the absorption of the medicine is prevented by the pressure on the vascular system, and without this absorption the proper action of the Purgative cannot take place, for it has no opportunity of passing out of the blood through the glands of the bowels. In such instances it is well to combine the Cathartic with a small dose of Tartar Emetic or Ipecacuanha, which by its nauseant operation may diminish the vascular pressure, and thus favour the necessary absorption. The action of a Cathartic itself favours absorption, by draining away the fluid part of the blood, and so diminishing the tenseness of the vessels.

Ord. IV. Cholagogues.

Medicines which are thought to stimulate the action of the liver, and to promote the excretion of bile, are called Cholagogues.

The Bile is a viscid fluid of sp. gravity 1020, having an alkaline reaction, containing in solution a sort of soap, formed by the union of soda with two peculiar organic acids, a yellowish-green colouring matter, some fatty compounds, and a crystalline principle (Taurine.)

There is no doubt that the function of the liver, regarded simply as a gland, is of great importance in the animal economy. We know that certain matters are excreted from the system by that organ, which, when allowed to remain in the blood, as in the case of jaundice, are found to be hurtful. Also it appears that certain other parts of the bile are secreted or formed by the same gland, for the purpose of being re-absorbed into the blood from the intestine, and that they serve some useful purpose in the processes which go on in the circulation. (*Vide* p. 170.)

A disorder of the liver by itself, *i. e.* unassociated with diseases of other organs, is comparatively uncommon. A failure in the secretion of bile is evidenced more or less by the well-known icteric symptoms. Jaundice is often caused by an obstruction in the hepatic ducts. In such cases it is worse than useless to urge the liver to an extra formation of a secretion which can find no outlet. But other cases, in which the discoloration of the skin is in general incomplete, may be due to torpidity, congestion, or chronic inflammation of the organ. In such instances Cholagogues may be cautiously used; but when there is acute inflammation they may do harm; and when there is a probability of structural change in the liver, they may be useless.

The great majority of intestinal diseases, as also of chronic blood-disorders, are associated with a torpidity or derangement of the function of the liver. We find this to be the case with diarrhœa and constipation, with dysentery and cholera; as well as with ague, and remittents,—gout, and rheumatism,—phthisis, and scrofula. In all of these diseases it is of great importance to attend to the state of the liver. I have already stated that Quina and other Tonics are of very particular use in such cases of disorder of the hepatic functions, and have attempted to discover some explanation of this fact (p. 175.) But we are at present concerned with medicines which tend immediately to increase the secretion of bile. They are more or less applicable in all the disorders which have just been enumerated. All Cathartic medicines act as indirect Cholagogues. This is particularly the case with the drastic purgatives. There appears to be a vital connexion between the action of the intestinal canal and that of the liver, so that any process going on in the one will excite the function of the other. Thus the bile is poured out during the process of digestion; and the peristaltic motion and extra secretion produced in the bowel by the action of a purge, causes likewise a sympathetic formation and excretion of bile. It is supposed by some that this result is due to an irritation of the orifice of the hepatic duct in the duodenum, produced by the purgative medicine. We must either suppose the stimulus of the food, which produces the same effect, to operate in the same way,—or reject such an explanation as superfluous, which appears to me the better alternative. For it is probable that the action of a Purgative is not at all exerted in the duodenum, but that it is actually absorbed there, and works out its operation in the lower part of the small, and in the large intestine.

True Cholagogues.—We are not well informed as to the exact number of medicines which pass out into the secretion of bile, and act thus on the true eliminative plan. But there is no medicine which is of such great and universal utility in all liver diseases as Mercury,—in its various forms. Mercurials increase more or less all secretions; and even if we had no direct proof of their action on the liver, we might almost have affirmed that they especially increased the secretion of bile, from the obvious way in which bilious symptoms yield to their action, and from the green colour of the fæces produced by Calomel. But we have still more direct proofs of this. Although Simon found that the normal fæces contained little, if any, biliary matter, he discovered in them 21·4 per cent. of the organic principles of bile after the operation of a large dose of Calomel. More recently M. Buchheim has made some careful experiments on a dog. Having given it Mercury, he cut down upon the hepatic duct, observed and collected the secretion, and subsequently analyzed it. He found that the bile was increased, and that Mercury was contained in it. (*Vide* p. 329.) An abundant vomiting of bilious matter is enumerated by Orfila among the symptoms of poisoning by corrosive sublimate.

Probably Manganese should occupy the next place to Mercury as a Cholagogue. Gmelin found that an extraordinary secretion of bile was produced in animals to which the Sulphate was administered. (*Treatise on the Action of Barytes*, 1824.) This salt is also a purgative. Certain other purgative medicines are popularly, and perhaps correctly, esteemed as specific Cholagogues. These are Rhubarb and Aloes. Taraxacum is also thought to act upon the liver. But of the true eliminative action of these medicines we have no proof.

It is probable that Alkalies, and Fatty matters, may act in certain cases as true Cholagogues, for they are both contained in the natural secretion of bile, and therefore likely to pass into it. Boerhaave recommended for the purpose of acting on the liver, soaps, "saponaceous herbs," and sweet fruits. The latter contain neutral salts which are changed into alkaline carbonates in the blood.

In many cases of debility, and even of Scrofula, small doses of Mercury may act efficiently as tonics, by stimulating the function of the liver, which in such instances is generally deranged.

Ord. V. Diaphoretics.

These are medicines which tend to promote the secretion and exhalation from the surface of the skin. Of the matters which are given off from the surface of the body there are three kinds. Water in the state of insensible vapour, and volatile matters,* are continually exhaling from the skin at all points, and pass unnoticed into the atmosphere around. The liquid sweat, which in the ordinary state of the body is only given off in sufficient amount to prevent the skin from becoming over-dry, is secreted by the sudoriferous glands, whose ducts terminate in large numbers on the surface at every part.† There is in the third place an oily material, formed for a similar purpose by the sebaceous glands, which are widely distributed, but fewer in number than the last. Diaphoretics seem to increase only the first two kinds, viz. the aeriform transpiration, and the liquid sweat; and they act upon these in a varying proportion. In the consideration of this order we have not only to bear in mind the distinction between these two kinds of diaphoresis, but to note further the important relations existing between the action of these medicines and the state of the atmosphere, the condition of the body, and amount of other secretions.

In all relaxed conditions of the general system, the amount of the perspiration is apt to be increased. This is especially evident in the weakness which follows a paroxysm of simple fever. The force of the heart is weakened, the tone of the capillaries impaired,—and by these conditions absorption is favoured, and the amount of fluid in the blood increased. At the same time the muscular system is relaxed, and the sudoriferous ducts being thrown open by the diminished contraction of the involuntary fibre that surrounds them, the excretion of the sweat is favoured, and the watery parts of the blood are poured out through the skin. This general relaxation precedes and follows the act of vomiting, as in-

* Among these is Carbonate of Ammonia. The volatile salt was discovered in the sweat by Tachenius in the seventeenth century.

† The density of this liquid is very various. It contains free Lactic acid, also Acetic and Butyric acids, salts of these with Ammonia and the fixed Alkalies, and Chloride of Sodium. M. Favre has found Urea in it, but not Carbonate of Ammonia. (*Archives Gen. de Méd.*, July, 1853.)

duced by a dose of Tartar Emetic or Ipecacuanha. Thus these medicines act indirectly as Diaphoretics, when given in emetic doses.

True Diaphoretics.—The following groups of medicines may be briefly noticed as tending to act as Eliminatives on the glands of the skin. Five divisions may be made:—1. Salines and diluents, under certain conditions; 2. Volatile substances which are soluble in air, as Ammonia, volatile oils, and Alcohol; 3. Certain acrid matters, as Guaiacum; 4. Certain Narcotics, as Opium and Camphor; 5. Antimony, Mercury, and Sulphur.

These Diaphoretics are all more or less uncertain in their action, as we have seen to be the case with Expectorants. There are two causes of this uncertainty. In the first place, the secretion of sweat, like that of the lungs, cannot be considered as a common emunctory. There are hardly any solid matters in it which are not also contained in the urine, and commonly excreted by the kidneys. It is only in special cases, or when there is a fault in the normal formation of urine, that the skin is called upon to eliminate materials from the blood.

In the second place, there are certain atmospheric and other conditions which promote the secretion of sweat, and certain others of an opposite nature which tend to retard it, and to divert into another channel the aqueous materials which should pass into it. With regard to the state of the atmosphere, warmth favours diaphoresis, cold repels it. Warm dry air, especially when in motion, promotes the aeriform transpiration, by favouring evaporation. Moist air, which hinders evaporation, promotes liquid sweating. Very active exercise, with the surface warmly clad, produces liquid perspiration. Moderate exercise, with a cool surface, favours diuresis. The recumbent posture, and sleep, promote diaphoresis; the erect posture, and wakefulness, diuresis. Thus when it is required to produce sweating, the patient is ordered to lie in bed, to be covered warmly, and to compose himself to sleep. Anything which keeps the surface of the skin unnaturally warm, as a hot-air or hot-vapour bath,—or thick-flannel clothing, which is a non-conductor of heat, tends powerfully to cause diaphoresis. So does friction, which stimulates and dilates the external capillaries.

So far the conditions of sweating and of diuresis are nearly opposite. But this is not the case with the medicines which are used to cause them.

Diluents, and salines soluble in water, form the first group of true Diaphoretics. Water promotes alike the function of the skin and of the kidneys; and it is only by a regulation of the circumstances mentioned above that it can be diverted from the latter towards the former. Diluent drinks are indispensable adjuncts to a Diaphoretic regimen. Salines also tend naturally to pass off in the urine, when in small doses; but when in large amount, by the bowels. A saline, being soluble in water, cannot pass out except into a fluid secretion; so that a saline Diaphoretic should be given in a moderate dose, and to secure its action the skin should be kept covered and warm, and the patient in the recumbent posture. The medicine will then pass off into the liquid sweat, as it otherwise would have passed into the urine. The alkaline Acetates, Citrates, and Tartrates, are especially applicable as diaphoretics in cases where there is likely to be an irritating state of the perspiration, as in Rheumatic fever, Gout, and some skin diseases. For, as they are converted into alkalies in the blood, and may thus pass into the cutaneous secretion, they would be able to counteract any excess of acid contained in it.

Volatile Diaphoretics may increase the cutaneous transpiration, and pass off by the skin, without the production of sensible liquid sweating. For being soluble in air, and capable of being carried away by it, they therefore tend especially to the two aeriform secretions, *i. e.* those of the lungs and of the cutaneous surface. (*Vide* pp. 334, 341.) Ammonia and its various salts are very useful as Diaphoretics. Volatile oils are less energetic, for they often pass off with such ease as not sensibly to increase the secretion of the skin.

Some acrid matters, as Guaiacum, Mezereon, and Senega, appear to act specifically on the function of the skin. So also do certain Narcotics, among which Opium is conspicuous as the most certain Diaphoretic that we possess, though its other operations prevent it from being applicable in all cases.

Antimony, Mercury, and Sulphur are medicines which appear to a greater or less degree to increase all the secretions in the body. When given in the insoluble form, they are reduced by the system to a soluble state. When Tartar Emetic is given in small doses, its only apparent action is slightly to increase the perspiration. It is probable that it then passes out through the glands of the skin. When given in emetic doses, it may produce sweating indirectly, as mentioned above. Iodine, which also increases secretion generally, acts sometimes as a Diaphoretic.

Many volatile oils have been detected by their odour in the perspiration, as those of Garlic, Onion, Asafœtida,* Musk, and Copaiba. Mercury, Sulphur, and Iodine, have been detected chemically in it. It has happened, when a course of Mercury has followed the administration of Sulphur, that parts of the skin have turned black, from the formation of Sulphuret of Mercury. So it is proved of many of these Diaphoretics, and thus rendered highly probable of the rest, that they are true Eliminatives, being themselves excreted by the glands which they excite to action.

When copious diaphoresis has been excited, care should be taken that it be allowed to subside gradually, or the consequences may be hurtful. It may be remarked that cleanliness of the surface, by which the sudoriferous ducts are kept open

* Trousseau and Pidoux. *Traité de Thérapeutique*, pp. 12, 13.

and healthy, is highly important to the proper function of the skin.

Diaphoretics are useful in various disorders. In what is called *a cold*, when the function of the skin has been suddenly interfered with, and the vaporous transpiration is all thrown upon the lungs, producing irritation or inflammation of the respiratory mucous surface, Diaphoretics are generally required. In Fevers, and some other disorders, as Gout and Rheumatism, which are apt to improve or to pass off with an increase of perspiration, and in which it often seems likely that some morbid materials may be eliminated by this channel, the same medicines are constantly necessary. This natural determination of exanthematous and other disorders is perhaps not sufficiently regarded by modern physicians. The chief treatment of fevers among practitioners of a century since consisted in copious and frequent sweating. Their successors, in recommending light clothing and cool apartments,* and thus discouraging the function of the skin, have gone to the opposite extreme. There can be no doubt that the old plan met with a very fair amount of success, especially when we take into account the concurrent practice of blood-letting and other acknowledged errors of treatment. And I believe that in these disorders we may often do great good by stimulating the secretion of the skin with warm clothing and efficient doses of saline or antimonial diaphoretics. We may thus produce an artificial crisis, and hasten the termination of a dangerous disorder.

When another secretion is unduly copious, an increase in the sweat may cause it to diminish. Thus in some cases of diarrhœa, and still more in diabetes, Diaphoretics are appropriate. In contrary conditions, as when the formation of urine is unnaturally small, on account of granular degeneration of the kidney, it is again important to stimulate the secretion of

* This was first advised by Sydenham, but it was very long before the practice was really adopted.

the skin, that it may, if possible, be able to replace the other. (*Vide* p. 337.)

ORD. VI. DIURETICS.

These are medicines which tend to increase the secretion of urine.

By means of the kidneys a large amount of aqueous material is every day separated from the blood, and excreted. This water is in the first instance absorbed by the surface of the stomach and intestine. The causes which demand its excretion are twofold. In the first place, it is necessary that the blood should be kept down to its normal standard as regards water, and that the surplus fluid which is daily added to it should be removed. Secondly, this water is required in the urine as a vehicle, to hold in solution there certain soluble matters which are continually forming in the blood, or being received into it, but which have to be excreted from it by means of the kidneys. These matters comprehend a variety of salts,—and a number of nitrogenous substances, of which the best-known are urea and uric acid. These last are formed in the blood by the gradual decomposition or change of the animal tissues through which it flows. When retained in the circulation, on account of a failure of the function of the kidneys, they act as poisons.

The kidneys are the chief emunctories of water; and mineral substances which are soluble in water tend for this reason to pass out into the urine. Many of these, as the salts of Iron, Silver, Lead, and Copper,* are Astringents, and tend to diminish rather than to increase the amount of urine. But the urine is so necessary and so constant a secretion, that it is very difficult to diminish it in quantity. Saline medicines act as Diuretics under certain conditions. So also do acids and

* According to Flandin and Danger, this metal passes into the urine with the greatest difficulty. (*Comptes Rendus*, July, 1843.)

alkalies, and many vegetable substances, which will be presently spoken of.

The soluble substances which thus pass off in the urine, and act as Diuretics, are many in number, but they are all uncertain in action, for several reasons. The amount of the urine depends very much on the quantity of water taken into the stomach, or absorbed from the atmosphere through the skin, so that when there is not a sufficient quantity of water in the system, it is impossible for more urine to be formed. This necessary absorption of water depends again upon the pressure of the circulation; when this is too great it cannot go on, and the urine is diminished. A large increase in any other of the secretions, as that of the bowels,—but particularly of the skin, as in warm dry weather,—hinders diuresis. The secretion of the urine is favoured by those conditions which repress the perspiration; as by coldness of the surface, light clothing, a cold and damp condition of the atmosphere, and the erect posture. In the fourth place, the urine is diminished by causes which impede the circulation, as by congestion of the kidney or liver,—or of the whole venous system, on account of obstruction in the heart,—conditions which produce dropsy.

Those medicines act as indirect Diuretics, which, by favouring the removal of one of these hindering causes, tend to allow the secretion of urine to go on as in health. The powerful action of the heart in fevers and inflammations causes such a pressure on the vessels as to retard absorption, and thus hinders diuresis. A hard bounding pulse and hot skin favour sweating more than diuresis, though they often diminish both of these secretions. Both are assisted by a relaxed state of the circulation, which favours the absorption of fluids. Thus venesection, purging, Antimony, or anything that diminishes a febrile reaction, will help diuresis in such cases. In cases of congestion on account of cardiac disease, Digitalis, which, by powerfully weakening the force of the heart, both diminishes congestion and favours absorption, is a most efficient promoter of the natural function of the kidneys.* When the portal circulation is the seat of the obstruction, a mercurial, such as blue-pill, which especially acts on the liver, will be a most desirable adjunct to the other remedies employed. Tobacco and Lobelia, like Digitalis, promote diuresis by diminishing the force of the heart.

True Diuretics.—Though all true Diuretics pass into the urine, the converse of this, *i. e.* that all matters which pass into the urine are Diuretic, is not always true. Thus the astringent mineral salts pass frequently out of the system in the urine, but seldom affect its amount in either way. And for the reasons already enumerated, it is often impossible, even by the most powerful medicines of this order, to increase the urine beyond a certain amount.

Diuretics may be somewhat loosely arranged in four groups: —1. Water, and soluble mineral substances, *i. e.* acids, alkalies, and salines under certain conditions; 2. Acrid matters of various kinds; 3. Alcoholic and ethereal liquids; 4. The minerals which increase all secretions.

Diluents promote the secretions of the skin and kidneys. A certain quantity of water must be given with every diuretic dose, and the larger the quantity the greater will be the effect produced. In the case of a Diaphoretic, this is all that is required. But as Diuretics are generally given, as in dropsies, for the purpose of eliminating fluid out of the system, this object would be clearly defeated by the introduction of a large quantity of water into the system. This therefore should be avoided. The free acids, both mineral and vegetable, with the exception of Sulphuric acid (*vide* p. 318,) pass into the

* Dr. Christison found that a strong infusion of Digitalis applied to the abdomen externally in a case of Ascites, produced such an elimination of fluid from the kidneys, that the dropsy was cured. In addition to its action on the heart, Digitalis is probably a true Diuretic.

urine, and act as Diuretics. So also do the mineral alkalies. As these medicines have important agencies in the blood, and tend further, by altering the reaction of the urine, to produce in it deposits of different kinds (*vide* p. 186,) they cannot always be safely employed for this purpose. Salines are more appropriate. They should not be given in large doses, for they will then act upon the bowels. The dose should be small, and moderately diluted with water. To prevent it from acting upon the skin, the conditions which favour diaphoresis should be, if possible, avoided. The subject of the action of saline medicines, and the effect of dilution upon this action, has been already considered. (p. 80.)

When an alkali as well as an eliminative is required by the nature of the case, such a medicine as Acetate of Potash is often preferable to a free alkali. It has been found very useful in Skin diseases by Dr. Easton, and in Rheumatism by Dr. Golding Bird. In both cases, as a diaphoretic, it may correct an acid state of the perspiration, being excreted as an alkali; in Rheumatism, acting as a diuretic, it may counteract acidity of the urine.

The acrid Diuretics are perhaps the most powerful medicines in the order. One of them, Cantharides, is an animal product.* Some contain or consist of volatile oils: as Juniper, Turpentine, Cajuput, Copaiba, Horseradish. These volatile oils may act upon the skin instead of the kidneys, under the conditions which are mentioned above as favouring diaphoresis. Others of this group contain peculiar vegetable principles; as Broom, Chimaphila, Taraxacum, Colchicum, Digitalis, and Squill.

Alcohol, Ether, and Nitric ether, act powerfully both on

* Its acrid principle, Cantharidine, becomes soluble by means of alkali in the intestine, and so enters the blood. This compound with an alkali, according to Mialhe, has no irritant properties. But in the renal apparatus it meets with an acid which again decomposes it, and liberates the irritant Cantharidine, which thus is enabled to act as a powerful stimulant diuretic.

the kidneys and on the skin. Wine, which further contains certain volatile oils, and sometimes a vegetable acid, acts on the kidneys when drunk in any quantity. The diuretic effect of these liquids is, as in the case of salines, greater when the surface is cold, and less when it is warm and covered.

Mercury, Antimony, and Iodine, which increase, more or less, all the animal secretions, act, among others, upon the secretion of urine. Iodine particularly is said to be diuretic. In cases of Lead-poisoning, the Iodide of Potassium is thought to have a special action. It seems to carry off into the urine the lead that is retained in the system, by forming a soluble double salt with the insoluble Chloride of Lead. Mercury and Antimony are most efficacious as indirect agents; the former by stimulating the function of the liver when impaired, the other by diminishing the pressure on the vessels in febrile cases.

A large number of Diuretics are themselves secreted by the kidneys, and have been proved to pass out into the urine. A great many have been detected in the urine by different chemists, especially by M. Wöhler. The Carbonate, Nitrate, and Chlorate of Potash, and the Iodide of Potassium, have been found there. So also have the mineral acids—the vegetable acids—Magnesia—Mercury,* in combination—and Iodine, in the form of Hydriodic acid. Among vegetables, the principles of Chimaphila and Uva Ursi—the oils of Turpentine and Juniper, somewhat altered in nature—the oil and resin of Copaiba—and the acrid principle of Cubebs, all pass into it.† An animal product, Urea, a constituent of the na-

* It has been asserted by Dr. Murray that it is impossible for Mercury to pass off in the urine, on account of the Phosphoric acid contained in that secretion, which would precipitate the metal. But Phosphoric acid is also contained in the blood: and Mercury has been discovered in the urine.

† The passage of the resins and balsams into the urine was noticed by Boerhaave. He stated also that Cassia fistula in a small dose turns it *green;* in a greater quantity, *brown;* and in a still greater, *black.* (*op. cit.* p. 239.)

tural urine, which may be artificially produced, is an admirable diuretic. Other substances, which are not diuretic, but astringent, have been found in the urine; as Alum, Lead and the Morphia and Meconic acid of Opium.

When a powerful diuretic is given in too large a dose, it may cause a degree of action sufficient to produce congestion of the kidney, and so defeat the object for which it was intended. For congestion of a gland is invariably followed by a diminution or stoppage of its secretion. So a large dose of Turpentine or Cantharides may cause a dangerous attack of strangury, or even a total suppression of the urine for a time. (*Vide*, p. 331.)

It can hardly be said that Diuretics are of very extensive application in the treatment of disease, or that they are medicines which can ever be much relied upon. For not only are the remedies themselves uncertain in action, but it happens also that the disorders in which they are most required are of a peculiarly obstinate nature.

There are two chief actions for which Diuretics may be required. They may be used: (1.) To eliminate solid materials from the blood; (2.) to promote absorption, by diminishing the amount of fluid in the blood. It is easier to employ the first than to exert the second of these operations.

When there is habitually a deposit in the urine, of lithates, or phosphates, or other solid matters, the simplest mode of obtaining a solution of this deposit, and thus preventing dangerous consequences, is to increase the amount of the fluid part of the secretion. Water is the best medicine for this purpose, and all Diuretics that are given with such an object should be freely diluted with water. In Gout and Rheumatism, remedies of this order may be of service by promoting the excretion from the blood of the uric or lactic acid formed there. They may also be used as Eliminatives in fevers and other disorders. In the strangury which may sometimes follow the application of a blister to the skin, copious draughts of water are often prescribed with advantage, for they serve to wash out of the blood the acrid matter which has been absorbed from the surface.

It is for the second purpose, in cases of dropsy, produced by congestion of the liver, kidneys, or general circulation, that Diuretics are most urgently required, but are least efficacious. This congestion and pressure on the veins diminishes the amount of the secretion of urine, and by so doing increases itself, and aggravates the effusion and disorder. The same cause most effectually hinders the action of a Diuretic. If only we could largely increase the secretion of urine, the pressure on the venous system would be diminished, and absorption of the effused fluids might take place. Dr. Christison has recommended the use of diuretics in Bright's disease. But in most cases of dropsy caused by renal congestion, the attempt to act on the kidney is so hopeless that it is better to resort to Diaphoretics. In obstruction on account of heart-disease, or congestion of the liver, we may sometimes gain our point by combining other Diuretics with Digitialis or Blue-pill, remedies which tend to remove the causes by which the diuretic action is hindered. (*Vide* p. 357.) Even then we can often produce a much more copious and effectual drain of fluid from the blood by an action on the bowels, as by a dose of Jalap or Elaterium. When a Diuretic is required to eliminate fluid from the system, the dose should not be much diluted with water; this should only be done when we desire to eliminate solids from the blood. It is often advisable to combine together a number of different Diuretics in the same prescription, so that by their joint but various agencies the causes which hinder their action may be overcome. The operation of Diaphoretics is opposed to that of Diuretics, but it is not always so with purgative medicines. The urine is often increased by the action of a hydragogue Cathartic; and a combination of Blue-pill and Squill supplies us with one of the best of known Diuretics. It is applicable in cardiac dropsy as well as in hepatic cases.

The action of some stimulant diuretics, especially Copaiba, in the cure of gonorrhœal discharges, may perhaps be simply due to the local action of the medicine, as it passes, dissolved in the urine, over the inflamed mucous surface.

Thus is concluded a brief outline of the actions and uses of the six orders of Eliminative medicines.

CHAPTER IV.

ON THE ACTION OF SOME OF THE MORE IMPORTANT MEDICINES IN PARTICULAR.

THE chief objects for which I have designed this Fourth Chapter are that I may be enabled to illustrate some general principles of the action of medicines which have been laid down in the Propositions, and show in what manner they are applicable to special cases,—and to enter into certain details respecting the more important remedies, which have not been attempted as yet. Of many of these medicines a tolerably full account has already been given; but they may again be mentioned here for the purpose of shortly summing up their several actions, and comparing them one with another.

It often happens that there is more than one point of view from which the action of a medicine may be regarded. For many medicines are numbered under several distinct heads, being included in different groups on account of the several phases of their operation. There are three stages in the progress of the remedy through the system, at each of which it may exert a special action. There is a contact with the surface; a continuance in the system; and a passage out of the system. In the first place a medicine touches the mucous surface of the alimentary canal; here some few evidence their action. From this, if in any way soluble, it passes into the blood. Here it may act on the blood, being Hæmatic. Or it may employ the blood merely as a means of transit, and direct itself towards nerve or muscular fibre, being Neurotic or Astringent. But we have seen that none of these medicines, with the only exception of Restorative Hæmatics, can remain long in the system. They must pass out, and the mode of passage is through the glands. Here is a third opportunity of operation. The medicine may act now as an Eliminative, increasing the secretion of the gland; or, more rarely, as a glandular Astringent, because tending to diminish it.

As a general rule, though not in all cases, the most important action of a medicine is that which it first evidences, the subsequent operations being secondary, and of less moment. Thus Mercury is, in the first place, a Catalytic Hæmatic; in the second place, an Eliminative. Creosote is firstly a general Sedative, secondly an Astringent. Antimony probably belongs to three out of the four classes, and its second operation is perhaps the most important. It is a Catalytic, a special Sedative, and also an Eliminative.

COD-LIVER OIL.

Class I. Div. I. Ord. I. ALIMENTA.

This oil has been proved by the experience of many physicians to be a medicine of great utility in most cases in which there is a morbid deficiency of fat in the system. It appears that the oil from the livers of fishes was used as a remedy among the Hindoos and Burmese in very ancient times. Cod oil was recommended in England by Dr. Percival, as useful in the treatment of chronic rheumatism, in 1771. But to Dr. J. H. Bennett belongs the high honour of having clearly pointed out its remarkable efficacy in tubercular diseases, in his '*Treatise on Oleum Jecoris Aselli*,' published in 1841. It is thought to exert a specific action in the cure of pulmonary

Phthisis, and it certainly appears to be the only medicine that possesses any marked or peculiar power over the progress of this disorder. When administered in favourable cases it seems not only to have the power of fattening the patient, but to be able also to combat and cure the disease itself, arresting or retarding the tubercular deposit. Sometimes it is unable to do this; but in all cases of consumption a trial should at least be given to it. It is of most service when the disease is only incipient, and, if given in the first stage, may often prevent its further progress; but it may even cure patients in whom the deposit has passed the stage of softening, as appears from the reports of the Brompton Hospital. Dr. Wood, of America, infers from the statistics of disease in that country, as observed by him during several years, that the extensive use of this oil in consumptive cases has been rewarded by the recovery of at least one in every eight, and he anticipates a still more successful result from the continuance of its use.

It is also of use in Scrofula, in chronic Rheumatism, and in cases of emaciation generally. It may prove nutritive in Diabetes mellitus, because it is not likely to be converted into sugar in the system, whereas in that disorder all kinds of food, excepting fats and oils, are liable to this change. Cod-liver oil is assimilated to the tissues, and there seems to be something in it which not only renders it more easy to assimilate than other oils, but which further endows it with a special influence over tuberculous diseases. It does not appear that any other oils are equally effective. Though Dr. Duncan and Mr. Nunn have recommended Almond-oil instead of Cod-liver oil, yet the general experience of others is decidedly against such a substitution.

It has not yet been clearly ascertained to which of the constituents of this oil its valuable properties are owing. Being itself an animal product, it is for that reason more easy of assimilation than a vegetable oil. Many have attributed its virtues to Iodine, of which, according to De Jongh, it contains 37 parts in 100,000.

Dr. Theophilus Thompson has tried both Olive and Almond oils in consumptive cases, but has not found that any material benefit is derived from their use. He has tried Cocoa-nut oil, with somewhat better results.* He considers that Cod-oil produces its best effects in cases where Iodine would be inadmissible. Neither does he think its virtue to be due to the biliary matters which it contains, for a mixture of ox-gall with Almond-oil does not supply its place. Cod-oil contains 21 parts in 100,000 of Phosphorus. Dr. Thompson supposes that its efficacy may be partly owing to this. He has made trial of Phosphuretted Almond-oil, containing one grain of Phosphorus to the pint. He suggests that this Phosphorus may be of use in diverting some of the Oxygen from the tissues. This is to adopt Liebig's theory of the excess of Oxygen in Phthisis; an idea which is not very consistent with the experiments of Dr. Hutchinson on his Spirometer, from which it appears that the quantity of air inhaled at each breath by a consumptive patient is considerably less than in health, on account of a diminished capacity of the lungs. But when a continual fever has set in, an oxidation and waste of the tissues must certainly take place. (*Lancet*, October, 1851. See also Dr. Thompson's *Clinical Lectures on Pulm. Consumption*, 1854, lecture v.; and *Lettsomian Lectures*, 1855, lecture iii.)

The phosphorus in Cod-liver oil would soon be oxidized, and it would seem to be too small in amount to be of service in this way. If anything were thus needed as a pabulum for Oxygen, we might suppose it to be the oil itself that was thus burnt. It is probably in this way that all oils are of a certain use in Phthisis. The introduction of oil by the skin, as

* Dr. Garrod finds that Cocoa-nut oleine is apt to produce disturbance of the digestive functions, a result which seldom ensues from the use of Cod-liver oil.

by tradesmen of several classes, or by the method of inunction practised by the ancients, but which cannot conveniently be revived in modern times, has been shown by Dr. Simpson to afford a considerable degree of protection against tuberculous disorders. But there is something peculiar in Cod-oil. An alleged discovery by Winckler, that it contains a peculiar fatty base, *Propyline*, in place of the *Glycerine* of other oils, may perhaps afford us some clue to its undoubted superiority over the vegetable oils.* But the same chemical peculiarity may possibly exist in other animal oils. And I am not sure whether some of these animal oils and fats may not be used with great advantage in phthisical and scrofulous cases. I may make particular mention of common Butter, which, if eaten in large quantities by patients suffering from tubercular cachexy, will relieve the emaciation in a marked manner, and probably be found agreeable as well as effectual.

M. Berthé has instituted a series of inquiries into the capacities which different oily substances have of being assimilated. He concludes from his experiments that there is in the human system a "point of saturation" for most fatty matters. After being administered in excess for a certain time they will appear in the fæces; but their assimilative properties vary much. The period during which extra doses of vegetable oils are taken into the system and increase the weight, is stated to be only twelve days. For Butter, Whale-oil, and white Cod-oil, the period is one month. Ordinary brown Cod-oil continues to be absorbed for a much longer time than this.—(*L'Union Médicale*, 1857, *tom.* xi. *No.* 26.)

In attempting to explain the efficacy of Cod-oil, some urge that it does good by stimulating the lymphatic and absorbent system. Others suppose that its particles exert mechanically a beneficial influence in forwarding the healthy process of cell-formation.

Possibly the utility of this medicine may depend upon a combination of several constituents and various properties. It

* See article *Morrhuæ Oleum*, by the author, in the second and third editions of Dr. Royle's *Manual of Materia Medica*.

is an oil; and thus of use as an Aliment, and as a supporter of the respiratory function. It is an animal oil; and thus peculiarly adapted for being digested, absorbed, and assimilated to the adipose tissues of the human body. It contains Iodine and Bromine; which are useful as Alteratives or blood medicines, both in Phthisis and Scrofula. Their proportion will not seem so small when the large dose of the oil and its frequent repetition are taken into account. But their presence alone would not be sufficient to explain the utility of the oil. It contains also Phosphorus, a general Stimulant, which may prove of use when there is a failure of the nervous forces.

Sometimes the dose of the oil excites a most distressing nausea. This may perhaps be prevented by a judicious modification of the vehicle. It may be floated on an aromatic water, on a bitter infusion, on milk, on wine, or on cold tea, to suit various tastes. In other instances the dose is swallowed without inconvenience, but the patient is not fattened, nor is his condition in the least improved by it. In such incurable conditions it is probable that there is often an organic disease of the Pancreas, or a failure of the function of that gland. For it appears that the absorption of fats is partly effected by means of an alkali contained in the Pancreatic fluid. When there is reason to suspect this cause of the emaciation, it is advisable to saponify the oil by shaking it with a sufficient quantity of solution of Potash or of Carbonate of Soda. The dose will then be in a state of solution, and ready for absorption.

Cod-liver oil may be used with advantage as a vehicle for Iodide of Iron, in scrofulous cases. Two grains of this may be dissolved in each ounce of the oil.

SULPHURIC ACID.

Class I. Div. I. Ord. II. ACIDA.
Class III. Ord. I. ASTRINGENTIA MINERALIA.

This medicine acts chemically as an acid in the blood and in the secretions. When diluted it is easily absorbed, and meeting in the stomach with an acid secretion, it passes into the circulation without being first neutralized. If in small quantity, it is neutralized by the slight excess of alkali in the blood; if in larger amount, it may exceed this alkali, and displace and set free other acids in the blood, combining with their bases on account of its strong affinities. In all cases it increases the quantity of free acid in the system, and tends to render the secretions, as the urine, more acid than they were before. (*Vide* Dr. Bence Jones' *Animal Chemistry*, p. 49.)

By this chemical action Sulphuric Acid is rendered useful in alkalinity of the blood, which may occur in fevers; or of the urine, as in Phosphaturia. It thus acts as a Restorative Hæmatic. But it is not right that there should be more than a certain quantity of this acid in the system. So that when introduced in large quantity it must be excreted. It does not appear that it is itself excreted in the urine, though it may cause an excess of other acids in that secretion. On this point Dr. Bence Jones has made some careful experiments. (*Anim. Chem.* p. 75.) He finds that Sulphuric Acid does not pass off in the urine, either free or in combination, except when given in great quantity. Now it is found that Sulphuric Acid is of great use as an Astringent in diarrhœa. Placing these two facts in juxtaposition, it would seem that the acid, which is doubtless absorbed in the first place, must afterwards be eliminated from the system by the surface of the bowels. This is perhaps because the secretion of this mucous membrane is the one which is least likely to be deranged by the presence of the acid.

The free acid is an Astringent, and has the power of coagulating albumen, and causing the contraction of muscular fibre. (P. 313.) Though probably neutralized and combined while in the blood, it is free before absorption, and after excretion. Before absorption it is an Astringent to the surface of the stomach; after and during excretion, to the surface of the bowels. It is useful chemically in alkaline Pyrosis. Its astringent property explains its utility in *acid* dyspepsia, which appears at first sight incomprehensible. Lactic acid, or some similar acid, is poured out in excess by the glands of the stomach. Sulphuric acid topically constringes the muscular fibre of the ducts of these glands, and in this way diminishes their secretion.

The acid, if in excess in the blood, may tend to brace the system by causing a general contraction of the fibres of the voluntary muscles. But it is chiefly on account of its anti-dyspeptic agency, and its astringent action on the secretions, that the title of Tonic has been so often applied to it.

Next to that of the bowels, the acid appears to act most on the secretion of the skin. Probably there also eliminated in a free state, it is thus able to diminish excessive diaphoresis.

It is applicable in case of Hemorrhage, when this takes place from a mucous membrane, for it probably passes off in small quantities from all the mucous surfaces. It is very useful in diarrhœa. (*Vide* p. 353.) Being a special Astringent to the intestinal mucous surface, it may be useful in malignant cholera, especially if given in the early stage of that disorder. Dr. Fuller and others have spoken highly of its efficacy in the last epidemic. It was discovered by Mr. Herapath, of Bristol, to be the active ingredient of a secret medicine recommended by the Austrian government as a specific for this disorder. It was therefore extensively used at the first outbreak of Cholera in 1854, but was afterwards somewhat too impatiently rejected for remedies of far inferior efficacy. If it were proved to have failed at the height of the epidemic, when the disease was the most virulent, it only shared the fate of all other medicines. It should be given without hesitation in large and very frequent doses, considerably diluted with water.

POTASH.

Class I. Div. I. Ord. III. ALKALIA.
Class I. Div. II. Ord. I. ANTIPHLOGISTICA.
Class I. Div. II. Ord. III. ANTISCROFULOSA.
Class IV. Ord. VI. DIURETICA.

Potash is one of those medicines which have several distinct actions; but its various operations are comparatively simple in nature, and easy to comprehend. In the solid state it is powerfully caustic and corrosive, having a great affinity for water, and abstracting it from the animal tissues with which it is brought in contact.

When a dose of the solution, properly diluted with water, is administered internally, it passes first into the stomach, and either combines with the acid of the gastric juice, or, what is more probable, it becomes absorbed too rapidly to be neutralized by it. It passes then into the blood, and probably exists in that liquid in a free state, for the blood already contains a slight excess of alkali. However this may be, it certainly increases the amount of alkali in the system.

Its hæmatic action depends in great part on its power of neutralizing acidity. It is thus useful in cases of acid dyspepsia, heartburn, or gastrodynia, when it combines with the excess of acid which exists in the gastric secretion, and probably also in the blood. For the same reason it is useful in some cutaneous diseases that are connected with disordered digestion. It is employed in Gout and Rheumatism,* where there is obviously an excess of acid both in the blood and in the secretions. (p. 238.)

When Potash is administered in any quantity, it must be

* The Bicarbonates of Potash and Soda have long been employed in Rheumatic fever. Dr. Garrod especially recommends the former, in two-scruple doses. (*Med. Chir. Transactions*, vol. xxxviii., 1855.)

excreted from the blood. The secretion of alkalies is mainly performed by the kidneys, and by their agency we may render the urine neutral or alkaline, and thus counteract a tendency to lithic deposits. (*Vide* Solvents.) For this purpose Potash is preferable to free Soda, for the lithate of Soda is comparatively an insoluble salt.

The salts of Potash with vegetable acids change into carbonates while in the blood, and will render the urine alkaline.* M. Wöhler, who has demonstrated this fact, finds that it does not occur with the super-salts. Even the neutral salts escape the oxidation when they are given in such large doses as to act on the bowels.

Potash is thus a Restorative Hæmatic, and where, from any reason, alkaline matter is needed in the system, it directly supplies the want. But it has also other actions which render it Catalytic, and which are evidenced in disorders in which there is no such deficiency of Alkali. By dissolving Fibrine, it tends to prevent its deposition from the blood.† It thus interferes with the inflammatory process, and acts as a general Antiphlogistic. It is possibly by a similar action that it seems able to counteract the deposit of crude tubercle, and exerts

* It may be worth while to note here that this discovery of Wöhler though it was new to us, was in a manner known to our ancestors a century and a half ago. Any one who will study the old English medical classics, will find in them the germs of many modern ideas, supposed to be novel. "Dr. Pitcairn has demonstrated that the acid substances of vegetables taken into the stomach, are by the action of this part, and the lungs and heart, when they come into the blood-vessels, turned to *alcalious*."—*Mead on Poisons*, 1702.

† It also causes the destruction of the albumino-fibrinous elements of the blood and tissues, so that, by their degeneration, the amount of organic materials in the urine is increased, and their sulphur at the same time becomes oxidized into Sulphuric acid, which is found by Dr. Parkes to pass out in the urine in combination with the Potash. (*Brit. and For. Med. Chir. Review*, January, 1853.) The same experimenter finds that there is more Sulphuric acid in the urine of Rheumatic fever than in that of health; from which it is inferred that Potash may be of use by assisting in the elimination of this acid, and thus help to determine the disorder. (*B. F. Rev.* Jan. 1854.)

a special agency in the prevention and cure of strumous disorders. It is very useful in the early stage of Phthisis, and in all stages of Scrofula. In Syphilis, when occurring in scrofulous subjects, Potash has sometimes been used with greater advantage than Mercury.

Potash and salts have been used in Scurvy, by Dr. Garrod, on the supposition that there is in this disorder a particular deficiency of Potash in the system. But the facts brought forward in the article on Antiscorbutics would seem to be opposed to such an idea. When given in moderate doses, and not retained in the system, Potash and its salts pass out into the urine, and act as diuretics.

QUININE.

Class I. Div. I. Ord. IV. Tonica.

Though the utility of this important remedy is often of a sufficiently direct and obvious character, its precise mode of action is enveloped in no small degree of doubt and obscurity. This subject has been discussed at some length in the article on Tonics.

It appears from the character and results of its medicinal influence, that it is exerted primarily in the blood, and not on the nerves.* It is included in the Restorative group of Hæmatics, and the general results of its action differ widely from those of a Catalytic Hæmatic. It produces no marked effect upon the system in health. Its operation consists in the cure of general debility, however produced, and in the prevention of periodic disorders in the blood. Debility depends on a want in the blood, and not on any active morbid pro-

* M. Piorry considers that Quina cures Ague by reducing the size of the Spleen; but there is no proof that the latter is the Cause of Ague, or that Quina has any immediate influence in reducing it.

cess; and there are circumstances which render it likely that Ague may be curable by the supply of a similar want.

Quinine is also serviceable in Gout, Scrofula, Dyspepsia, and other disorders; in all of which other medicines, which stimulate the secretion of the bile, are more or less applicable. Torpidity of the liver is likewise a usual accompaniment of the various forms of debility, and occurs in intermittent, remittent, typhoid, and yellow fevers; in each of which this medicine has been recommended, and used with advantage. In fact it may be said, that in all diseases in which Quinine is used there is a failure in the secretion of bile; and in all diseases in which there is a failure in the secretion of bile, Quinine is serviceable.

There appears then to be some connexion between these two things. Certain of the constituents of the bile are formed by the liver out of the blood, for the purpose, apparently, of being again absorbed at some part of the surface of the intestinal canal. One of these, Taurine, has been shown to be to a certain extent analogous to Quinine. And it seems to me to be not improbable that this alkaloid may be of service in these disorders by supplying the place in the blood of this biliary matter, which for some reason may be needful in the animal economy,—or that it may actually become changed into the latter while in the system. Were this proved, its restorative action would be effectually cleared up.

Quinine may be given with more or less advantage in all fevers, whether intermittent or not, care being taken to administer it at a time when the pulse is soft, and the skin and tongue moist. The Peruvian bark was named by Geoffroi, "the antidote of fevers."

The Disulphate of Quinine (or Quina) is the preparation of the alkaloid which is most commonly used.

Arsenic is used in Ague and intermittent disorders, and acts on the Catalytic principle, but is not serviceable in the other cases in which Quinine is used. It is not a Tonic, nor does it seem to have any relation to the function of the liver. I have thought it advisable to restrict the term *Antiperiodic* to the *Catalytics* which are used in Ague. (*Vide* p. 178.) Quinine and Arsenic may both be employed in all disorders which put on an intermittent or periodic type. The chief of these is Ague or Intermittent Fever. It is perhaps easier to arrest the disorder by Quinine than by Arsenic; for Quinine may be given in large doses, which cannot be done with Arsenic. But the administration of the latter may be continued during the paroxysm, when the great febrile reaction forbids the use of the other. The dose of Quinine is apt to disagree with an irritable stomach, and to increase the fever. It is generally laid down that this remedy should not be administered when there is a quick, hard pulse, or heat and dryness of the skin. Some however have lately ventured to prescribe it to patients in high fever. It appears that there is a particular class of patients which in such cases will bear the administration of Quinine with impunity: while others are unfavourably affected by the smallest dose.

Dr. Pfeufer, of Heidelberg, recommends to administer it in Ague in a single large dose, some time before the paroxysm. Quina is given in Typhoid fever by some practitioners. It is then also prescribed in very large doses, which are to be continually repeated. It has been used in malignant Cholera, apparently with advantage.

It is perhaps at all times advisable to arrange so that the medicine shall, if possible, be taken after meals, for it is less likely to irritate a full stomach. And when it is thought proper to give it to a patient in fever, a small dose of Tartar Emetic or Ipecacuanha should be conjoined with it—not, of course, sufficient to produce vomiting, but so that an increase of the febrile excitement may be prevented.

Quinine is in all cases better tolerated by the stomach when the dose is considerably diluted with water. When given in Cholera, it is best to prescribe ten-grain doses every hour, diluted with half a pint or a pint of cold water, and acidulated with Citric acid.

A combination of Quinine and Iron is often of great service in feeble and relaxed conditions, where there is co-existent Anæmia.

Quina (the pure alkaloid) is soluble in Cod-liver oil, and may often be given with advantage in conjunction with it.

IRON.

Class I. Div. I. Ord. V. CHALYBEATA.

It has been shown, in the article on Chalybeates, that the action of Iron is of a distinctly Restorative nature.

There is in the blood a red colouring matter, called Hæmatosin. It is found by chemical analysis that Iron is an essential part of this substance. The existence of the right amount of Hæmatosin in the blood is of vital importance. It is contained in the red globules of the blood. When it is diminished in quantity, the number of these red globules is lessened in the same proportion. This produces a paleness of all the tissues, an inactivity of the muscular fibre, an impairment of all the animal functions, and a general languor and debility of the whole frame. This is Anæmia.

In all cases in which Iron is used there is a deficiency of this red colouring matter; and in all instances of Anæmia Iron is appropriate as a remedy. The blood has been analyzed before its use, and found to contain a smaller quantity of Hæmatosin and fewer red globules than in health. After its employment the blood has been analyzed again, and it is found that the amount of Hæmatosin and of red globules is increased.

Iron, then, is given in Anæmia. It is also given in cases of Scrofula, Cancer, Chorea, Hysteria, and other disorders, when these are attended with Anæmia. When this last condition is wanting, it seldom proves efficacious.

Iron, when given in moderate doses, remains in the system and enters into the composition of the blood. It is then a Restorative Hæmatic.

Some of the Salts of Iron are also Astringent. Thus the Sulphate and Sesquichloride may, by their topical action on the stomach, be of service in cases of atonic Dyspepsia.

Some theories that have been promulgated as to the relative power of the Salts of Iron have already been combated by me, as founded in error. It has been supposed that the Protosalts only are possessed of marked remedial efficacy; also, that the action of a chalybeate on the blood is in an inverse ratio to its astringent power. But the proved utility of the Sesquichloride is by itself an answer to both of these hypotheses.

In Anæmia produced by special causes, as by scrofulous or nervous disorder, we may often do most good by striking at the root of the evil,—employing a Catalytic medicine which shall be able to do this. In simple Anæmia Iron is of more use than any other medicine. It should be combined with exercise, air, light, and good living. In other disorders a combination of drugs is frequently of use. In chronic Ague, and in many cases of debility, Iron and Bark may be given together. Iron and Aloetic purges may be prescribed in Chlorosis and Amenorrhœa. A mild purgative should be occasionally given in all cases in which Iron is used. The Ammonio-citrate of iron,—the compound Iron mixture, which contains the Carbonate,—and the Tincture of the Sesquichloride,—are perhaps the best of the officinal Chalybeate preparations. The first of these is the mildest, and the last the most irritant of the three.

ANTIMONY.

Class I. Div. II. Ord. I. ANTIPHLOGISTICA.
Class II. Div. III. Ord. II. SEDANTIA SPECIFICA.
Class IV. Ord. II. EXPECTORANTIA.
Class IV. Ord. V. DIAPHORETICA.

The best Antimonial for general purposes, and the most characteristic in its mode of operation, is Tartar Emetic. In this medicine are exhibited three distinct varieties of action. The first of the terms which are applied to it above implies that it has a Catalytic action in the blood. As a Special Sedative, it is able to cause nausea and vomiting. And it acts upon the glands as an Eliminative; being a Diaphoretic and an Expectorant.

Tartar Emetic is one of those metallic salts which do not coagulate albumen. It, therefore, is easily absorbed, circulates readily with the blood, and is quickly excreted in the urine.

I have found it convenient to restrict the term *Antiphlogistic* to those medicines which counteract the inflammatory process by an action in the blood. In this sense it is applicable to Antimony; although this medicine is still better able to subdue inflammation by its powerful neurotic action.

The operation in the blood is naturally slower than the action on nerve, and is therefore less marked, and less immediately applicable. Antimony deteriorates and impoverishes the blood in very much the same way as Mercury,* and, if given in small and carefully-regulated doses, is simply a mild Antiphlogistic and Eliminative. It tends to increase all secretions, but particularly the exhalation from the skin and lungs, independently of the production of nausea (p. 390,) a symptom

* It diminishes the amount of the plastic elements of the blood (Richardson.) But its decomposing action is not so marked as that of Mercury. The blood action of Antimony is farther of a peculiar character. Even when taken internally, it tends to produce a pustular eruption of the skin, as has been found by Lepelletier.

which is not brought on by a small dose. It is probable that a diaphoretic dose of Tartar Emetic is actually eliminated from the skin and mucous membranes. Antimony is appropriate as a Diaphoretic in high fevers, and in cases where Opium could hardly be used. But Opium is preferable in cases where there is gastric irritation, and a weak compressible pulse.

The action by virtue of which Antimony has gained its high reputation as a medicine is of a different kind.* By an influence on the part of the nervous system, apparently the Vagus nerve, it produces first the state called nausea, and afterwards vomiting. The most important symptom in this nausea, and in the state of system which succeeds the vomiting, and continues for some time after it, is a depression of the action of the heart. At the same time the muscular system is relaxed, and the breathing is rendered slower.

This nausea is not produced to any extent by a mere irritant Emetic, such as Sulphate of Zinc, which acts externally, and takes effect immediately. The Antimonial cannot act so quickly; part of it must first be absorbed, so that it may reach the nerve. We know that it does not act by outward irritation, from the fact that if the solution be injected into the veins at any part of the body, it will equally produce nausea and vomiting. Antimony has no direct action upon the brain; it affects only a part of the nervous system. In the nausea we recognise a sedative action upon the nerves of the heart; and in the slow breathing, a similar action upon the nerves of the lungs. But it may be objected that the production of

* Mialhe (*op. cit.*, p. 30) attempts to explain the therapeutic action of Antimony on the supposition that it hinders the healthy process of oxygenation in the blood. But there is no proof that it does so, or reason to believe it likely. The same explanation is given by this writer of the operation of Arsenic, Phosphorus, Hydrocyanic acid, and Narcotics. To most persons the symptoms produced by these agents must appear so widely distinct as scarcely to be explainable on the same common ground.

vomiting is not a sedative action, for we know that the same symptom may be caused by a mere external stimulant. And yet there are several reasons which have induced me to conclude that this also is a sedative action. It would be inconsistent to suppose that Antimony could be a Sedative in producing nausea, and a Stimulant in causing vomiting. We have already noticed that a Sedative medicine may affect nervous force in either of two ways; it may derange it, or it may depress it. (p. 295.) That influence which causes the contraction of the stomach to commence at the pylorus, and to result in the expulsion of its contents upwards along the œsophagus, is obviously explained by an action of derangement, for it is an exact reversal of the natural state of things. (p. 107.) But the effects of derangement are often very similar to those of excitation. Thus, convulsions of the muscular system are caused by Hydrocyanic acid, a Sedative—and by Strychnia, a Stimulant; and vomiting is producible by Tartar Emetic, a Sedative,—or by an external irritant of the mucous membrane.

It is by the production of nausea that Antimony becomes so valuable an agent in the control of high fevers and acute inflammations. The force of the heart being diminished, the fever is allayed; and the active congestion of the vascular system, whether local or general, which was produced by the inflammation, and maintained by the violent action of the heart, is effectually subdued. At the same time absorption is favoured by the removal of the pressure from the capillary circulation.

For its power therefore as a Special Sedative, by which it produces nausea, Antimony is used in sthenic inflammations generally, especially in those that are rapid, and in which we desire a sudden and powerful action. In such cases it is preferable to Mercury,—which is a simple Antiphlogistic, acting in the blood, and having no operation on nerve. It is thus indispensable in Croup. It is very efficacious in sthenic Pneumonia. Laennec speaks highly of its use in acute Bronchitis. In Fevers, Dr. Graves recommends that it should be combined with Opium. In inflammation of the lungs it is particularly applicable, for it exerts a sedative influence over the nerves of those organs.

If a small dose be constantly repeated, and gradually increased to a large one, the system will at length be induced to tolerate the medicine, and it will not produce vomiting. Laennec recommended that it should be given in this way in inflammations. He considered the production of vomiting unadvisable; for by that act the system is temporarily excited, and a large quantity of the medicine rejected, which should have been absorbed in the blood to work out its action there. The soundness of his views on this point has been generally admitted by those who have succeeded him.

Given simply as an Emetic, this medicine has been used in the early stage of acute local inflammations, as Ophthalmia and Gonorrhœa. It may cut these short at their outset, by hindering the tendency of the local irritation to excite the force of the heart. When we wish simply to evacuate the stomach, as in a case of poisoning, an irritant emetic, as Mustard or Sulphate of Zinc, which acts at once without producing nausea, should be preferred: for three reasons. Its operation is more rapid. The distressing condition of nausea would be an aggravation of the existing mischief. And the production of nausea, by taking off the pressure from the vascular system, favours absorption, which is the very thing that we wish to avoid. The object of an antimonial Emetic is not so much to empty the stomach as to make a powerful impression on the system.

The influence of Antimony on the glandular organs is indirectly but powerfully intensified by its nauseant action. In small doses it is a simple Expectorant; in nauseant doses, it assists expectoration by relaxing the bronchial tubes, and diminishing the number of the respirations. In a small dose it is Diaphoretic; but in large doses it may cause copious sweating, by favouring the absorption of fluid into the blood, and dilating the capillaries and pores of the sudorific glands. In inflammatory habits a small addition of Tartar Emetic forms a powerful adjunct to a purgative dose; for by it the absorption of the other medicine is assisted, and at the same time an over-tonicity of the muscular fibre of the intestine may be diminished. But in relaxed conditions of the system, where the intestine is apt to be over-dilated, and Catharsis is favoured by Tonic medicines, Tartar Emetic would hinder it.

Ipecacuanha, a vegetable substance, resembles Antimony in all its operations, excepting its blood-action. It is less potent as a Neurotic; less efficacious as a Diaphoretic; but excels it as an Expectorant.

MERCURY.

Class I. Div. II. Ord. I. Antiphlogistica.
Class I. Div. II. Ord. II. Antisyphilitica.
Class IV. Ord. III. Cathartica.
Class IV. Ord. IV. Cholagoga.

There are three principal forms in which this medicine may be exhibited. Blue-pill contains the metal itself in a finely-divided state, as well as a small quantity of the oxide. Calomel is an insoluble Chloride of Mercury. From the great similarity that exists between the action of these two, it seems likely that they are reduced by the gastric or intestinal fluids to the same condition. Both must be rendered soluble (p. 99) before they can be absorbed.

Bichloride of Mercury is soluble in water, and probably absorbed without material change. It differs from the other two as a medicine, partly, but not entirely, on account of its solubility. The dose required is smaller, for it is much more powerful. It is also much more irritant, being in large doses a corrosive poison, and often producing soreness of the throat and of the urinary passages. It has been thought to be less likely to produce salivation. It is more frequently used in chronic than in acute diseases.

The *Physiological action,—i. e.* the inevitable operation of mercury on all persons, healthy or diseased,—may be stated in three theorems.

1. It is absorbed, and passes into the blood.
2. It disintegrates, or decomposes the blood, and wastes the body.
3. It is ultimately excreted, and passes out by some glands more than by others, increasing secretion, both healthy and morbid.

1. *It is absorbed, and passes into the blood.*—Without insisting on the argument that a medicine which produces such a manifest effect on the fluids, and on remote parts of the system, must of necessity be absorbed before it can act, I may be content with the statement that Mercury has been discovered in the blood of persons to whom it had been administered, by Wöhler, Tiedemann, and other chemists. So intimately does it become united with organic matter, that it is necessary to submit the blood to the process of destructive distillation before the metal can be recognised by the proper chemical tests. Not only has mercury thus been discovered in blood, but it has been detected while making its exit from the system, in various excretions. It has been found in the urine, the bile, the sweat, the saliva, the milk, and in pus on the surface of ulcers. It has been discovered in the solids after death, as in the brain, the bones, in the cellular tissue, in serous membranes, and the parts about joints, and in the lungs and liver. Mercury, wherever it is applied, if applied in the proper form and manner, is equally capable of reaching these distant parts and secretions. It can only reach them by becoming first absorbed into the blood, and passing through the system. Mercury, therefore, is absorbed.

In order to be absorbed, it must be capable of permeating the absorbent animal membranes, whether of the stomach or intestine, of the skin or the pulmonary surface: that is to say, it must be in such a state as to be *soluble* in the fluids of those surfaces. It is true that Œsterlen, of Dorpat, has recently affirmed that the particles of various insoluble substances, among others, of liquid mercury and calomel, are capable of passing through the animal membranes without first undergoing solution. He says that he has found globules of metallic mercury in the cellular tissue under the skin of animals, after rubbing in mercurial ointment. Dr. Bærensprung has carefully repeated the experiment, and discovered no such particles. Autenrieth and Zeller inserted a strip of gold beneath the skin of an animal, and on rubbing in the ointment over it, no stain was perceived. After dosing dogs with large doses of calomel and mercurial ointment, I have myself carefully analyzed the portal blood for mercury in the insoluble form, and by the aid of that most delicate of all tests for mercury, the galvanic combination of Smithson, but could find not the least trace of it. The other experiments put on record by Professor Œsterlen have in my hands invariably led to a negative result. Without depending so much on these negative experiments, for such a dependence is always hazardous, I think it may be most positively affirmed, from what we know of the function of absorption, that no substance whatever can pass through a living (and entire) animal membrane, without being in a state of solution and capable of mixing with the fluids on the other side.

How, then, is this state of solution obtained in the three forms of mercury in use as medicines? The problem, in the case of two at least, is a difficult one; but I may perhaps be able to throw some light upon it. Metallic mercury is not capable of solution in any of the animal fluids. To whatever part or surface of the body we present it, it cannot be dissolved; it cannot, therefore, undergo absorption. It is inert. But it is capable of undergoing change, and after that change it may affect the animal system. It was long ago shown by Boerhaave, that mercury, when agitated for some time in a flask in contact with air, became coated with a blackish crust. This is on account of an oxidation which the surface of the metal has undergone. The crust consists partly of protoxide of mercury. Moreover, mercury, like water and other liquids, though to a less extent proportioned to its great density and high boiling point, gives off some vapour at the ordinary temperature of the atmosphere. Dr. Wright has shown that this vapour undergoes partial oxidation in the air. It is by the agency of this oxide that artisans exposed to the vapour of mercury become liable to various diseases. Now, metallic mercury taken into the stomach produces generally no effect whatever, (except what is due to its weight, &c.,) because in most cases there is no oxygen or air in the intestinal canal, and the metal as drunk is quite pure. But sometimes salivation and other mercurial symptoms may result. This is either because the metal had been at the first slightly blackened with oxide, or because there happens to exist in the intestine sufficient atmospheric air to operate the necessary change.

In the formation of blue-pill, intended for internal exhibition, metallic mercury is triturated with confection of roses and powdered liquorice root, in the proportion of one-third of the whole weight, until its globules are mixed in, and reduced to so small a size that they cannot be distinguished with the naked eye. To make mercurial ointment, equal parts of mercury and lard are mixed in the same manner, the extinction of the metal being commonly promoted by the admixture of some old or rancid ointment. During these processes, on account of the extreme subdivision of the particles of mercury, an infinitely larger surface is exposed to the action of oxygen, and an appreciable quantity of oxide is formed.

Dr. Nevins finds that mercurial ointment contains on the average one grain of protoxide of mercury in 100 grains; blue-pill, three-quarters of a grain in 100 grains. The organic matter would seem to assist the oxidation, for hydrargyrum cum cretâ, a preparation analogous to blue-pill, but somewhat milder in action, contains only half a grain in 100 grains. The protoxide of mercury is, doubtless, the active part in each of these preparations. Unlike metallic mercury, it is soluble in many of the animal fluids. The acids of the gastric juice, and the lactic and butyric acids of the secretion of the skin, are capable of dissolving it. So also are the secretions of bile, saliva, and mucus, though to a less extent. When the ointment is rubbed into the skin, a much larger quantity of metallic mercury is exposed to the action of the air, and converted into oxide; so that it would be quite wrong to consider the portion of mercury which we discover in the metallic state in the ointment to be wholly inoperative.

Calomel, or Chloride of mercury, is quite as insoluble in water as the metal itself. But in some manner it is dissolved in the secretions of the stomach or intestines, for when taken into the stomach it passes into the system, and produces the characteristic effects of mercury. It was pointed out by Hunter that it is slightly soluble in the saliva, and can be tasted distinctly when it has been chewed in the mouth for some time. It seems also to be soluble in the mucous secretions, for its vapour obtains entrance through the pulmonary membrane.

In what manner is it thus dissolved? Mialhe, a distinguished French chemist, to whom is owing the acknowledgment, that by his researches he has thrown a clearer light on many an obscure point in therapeutics, considers that calomel is dissolved simply and solely by means of alkaline chlorides contained in the animal secretions, especially the gastric juice. By these a small proportion of the insoluble protochloride is converted into soluble bichloride of mercury. Mialhe considers that not only calomel, but all mercurial preparations, give rise to the production of bichloride of mercury during the process of digestion, and that all their therapeutic and toxic effects are owing to this salt. We find that when calomel is long boiled in pure water, a small proportion of bichloride ($Hg\ Cl_2$) is formed, a subchloride ($Hg_2\ Cl$) being probably produced at the same time. This transformation takes place more readily with a solution of an alkaline chloride, but requires long digestion and a high temperature, and even then the amount of soluble $Hg\ Cl_2$ produced is but small. The affinity of the chloride of sodium, or chloride of ammonium, for the bichloride of mercury, is thought to be the chief cause of its formation. In a number of experiments made out of the body, Mialhe found that if ten grains of finely-powdered calomel be digested for twenty-four hours in three ounces of distilled water, in which are dissolved ten grains of chloride of sodium and chloride of ammonium, at the end of that time about one-fifth of a grain of bichloride will be dissolved. On such facts he builds his statement, that corrosive sublimate is the one only mercurial which acts on the system. For he finds that the protoxide, binoxide, and all protosalts and persalts of mercury, undergo the same transformation, the protoxides and protosalts yielding about as much bichloride as the calomel, but the peroxide and the soluble persalts very much more.

But it seems to me that there is very great doubt as to the correctness of this theory. The soluble chlorides in the gastric juice would scarcely be sufficient for the purpose proposed. This is also the opinion of Œttinger. The stomach-secretion contains only ·5 in 100 of solid matters, and scarcely one-tenth of that consists of alkaline chlorides. As the action on the calomel diminishes in a rapid ratio with the dilution of the salt, the amount of the latter present seems too small to be able to effect any such change as that supposed. Moreover, the time naturally allowed for digestion in the stomach liquid, and the heat of the body at which the digestion is carried on, are both much less than what was allowed in the experiments of Mialhe.

Being, therefore, still in much doubt and uncertainty as to this matter of the solution of calomel, I have lately made some experiments with the hope of throwing some light on the subject. These, as far as they have yet gone, for I mean to continue and extend them—lead me to suppose that the *bile* exerts a far greater solvent action on calomel than any other reagent that the drug would be likely to meet with in the stomach or intestine.

The plan upon which these experiments are conducted is simply to digest five grains of fine and pure calomel, at a temperature of 100°, for twenty-four hours, frequently shaking, in one ounce of water holding in solution five per cent. of the material of whose solvent powers trial is to be made. The acid of the stomach, lactic acid, is tried in this manner. Bile is experimented with. So are solutions of the chlorides of sodium and ammonium; and glucose, produced during digestion in the intestinal canal,—a material which some French Chemists have affirmed to be possessed of the power of holding in solution in water certain very insoluble substances. Of all of these, bile, as obtained fresh from the carcase of the ox, is the only liquid that dissolves even an appreciable amount of calomel under the circumstances stated. Such is the general result of the experiments which I have made, a detailed account of which had better be postponed until I have completed that further investigation of the subject which I propose. I cannot at present pronounce any decided opinion as to the exact chemical condition to which the calomel is reduced by the action of the bile. This secretion contains, frequently, an excess of soda. It might seem probable that this would decompose the chloride of mercury, and form the black oxide. This is certainly the active ingredient in blue-pill, and to suppose it formed from calomel would at once provide us with an explanation of the similarity of the action of these two medicines. In adopting this explanation, we should encounter at once two difficulties. Firstly, the bile, if alkaline, would not dissolve the protoxide of mercury, which, in the case of a substance which had not passed beyond the stomach, might be acted on by the acid gastric juice. On the other hand, the bile, as was the case with that which I used, may be as nearly neutral as possible, and thus could hardly form any protoxide. The bile contains an acid, taurocholic or choleic, united with soda. It is just possible that, by a mutual reaction between this and the calomel ($Hg\,Cl$,) taurocholate of mercury and chloride of sodium ($Na\,Cl$,) might be formed, and the former salt absorbed. However this may be,—inasmuch as it seems that bile dissolves calomel to a much greater extent than a comparatively strong solution of an alkaline chloride,—I think we have but little reason to suppose, with Mialhe, that this calomel is only absorbed as bichloride. In conjunction with the solvent part of the bile, the mercurial may undergo absorption; and when afterwards, it has to quit the system, it seems to do so in main part by the secretion of the liver, just because it is soluble in it.

Bichloride of mercury, on account of its solubility and corrosive power, is far more active and poisonous than calomel. It is not, however, immediately absorbed. It is first precipitated by albuminous substances in the gastro-intestinal secretions, and the albuminate of mercury is next dissolved by means of alkaline salts. (This takes place with a minute—*i. e.* medicinal dose. A large quantity corrodes the stomach.)

With regard to the mercurial preparations as considered in the aggregate, or compared with one another, whether or not we admit the bichloride theory of Mialhe, the following statement may, I think, be made with tolerable confidence:—*The same amount of mercury in a soluble form will produce always the same effect upon the same system.* Thus the effects of ten grains of calomel may be compared with those of one-tenth of a grain of corrosive sublimate. But if all the calomel were dissolved, the action would be one hundred times greater. We have just enough solvent matter in the ordinary human system to take up $\frac{1}{100}$th part of the calomel, and no more; the rest passes out with the fæces.

Hence this great difference between insoluble and soluble mercurials. The first, as calomel, are variable agents. Their action does not in reality depend much on the dose given. This may often be increased with little effect. Until the amount of solvent matter in the stomach or bowels is increased, the amount of mercury taken into the system will be much the same. In fevers and cholera, when the dissolving power is little, and the function of absorption at a low ebb, calomel may often be poured in with no effect at all. As the patient recovers, a dangerous salivation may occur; and in some idiosyncrasies, some peculiarly susceptible states of the absorbent surfaces, one to two grains of calomel in the stomach, or one drachm of mercurial ointment rubbed into the skin, may be followed by violent mercurialism, or produce necrosis of the jaw, and death. Thus the action of calomel and blue-pill depends on the system, rather than on the dose, and is so far variable. Thus when a patient asserts that his constitution cannot bear mercury, it is advisable to be cautious, and often better to administer a small dose of the soluble than a large dose of the insoluble preparations.

It is not, however, to be supposed that in all cases a minute dose of bichloride of mercury can be substituted for a large one of the chloride or of blue-pill. The whole of the soluble salt comes immediately in contact with the mucous surface, and exerts on it a corroding and irritant action. Not so the insoluble preparation. Gradually and very slowly acted on by the solvent, the mercurial matter which is dissolved passes through the intestinal membrane into the blood, as fast as the solution takes place—not remaining long enough to irritate. We may diminish the irritation produced by the sublimate by making it into a firm pill with some organic matter. This pill will take some time to dissolve; and thus the irritation produced by the whole dose of sublimate acting on the mucous surface at once will be escaped. Mialhe proposes to imitate the natural conditions of absorption by precipitating the sublimate with white-of-egg, and dissolving this albuminate with chloride of sodium. But the albuminate, if given alone, is gradually dissolved, at least in part, in the intestine, and thus white-of-egg can hardly be considered an antidote to corrosive sublimate in cases of poisoning, except where the product of its union with the mercurial is rapidly and completely eliminated by vomiting. Before quitting this subject, I may touch on one more point connected with the therapeutic history of corrosive sublimate. I conceive that the reason why it so seldom produces salivation is simply that it is administered in such small doses on account of its irritant action. When the usual action of mercury on the system is produced by pushing this remedy to a sufficient extent, salivation takes place as one symptom of that operation. Not that I would recommend the use of larger doses, for it is seldom at all necessary to induce salivation in those cases where the sublimate is most used—*i. e.* in secondary syphilis, and in chronic diseases.

As to the doses and mode of administration of the mercurials in common use, I may make two remarks:—Firstly, that very much smaller doses of calomel and blue-pill, than such as are usually given will produce much the same effects, because sufficient to exhaust the solvent power of the system. Thus Dr. Law has shown that one-twelfth of a grain of blue-pill given every hour for twenty-four hours will produce a salivation. Then, as to the particular mode of giving these medicines, I believe that the result on the system is just the same eventually, whether we rub in the ointment, give the medicine by the mouth, or cause fumes of calomel or the oxide to be absorbed by the cutaneous or pulmonary mucous surface. The difference seems to be this: the effect of mercurial ointment, rightly applied, is most constant; that of calomel and blue-pill internally, more variable; that of the fumigation, the most variable of all. Surgeons will be guided in their selection by their experience of particular cases, or classes of cases.

In many old histories of syphilis, it is too painfully apparent to us that a large part at least of the recorded symptoms was due to the enormous amounts of mercury given. This practice generally arose from the notion that the elimination of the morbid poison depended solely on the continuance and degree of salivation. A practice also becoming less usual, and, as I think, for many reasons, properly so, is the constant combination of a mercurial with opium. Many of the recorded effects of these two in fevers, etc., are probably attributable to the opium alone, the calomel which accompanied it not being easily absorbed in such cases; and in syphilis, when there is already salivation, or when it is difficult to produce it, the combination of calomel with opium is dangerous. By it the mineral poison is concentrated in the blood, and hindered from being eliminated. By this the various so-called mercurial diseases may be caused; or a tremendous determination towards the region of the salivary glands may lead to results of a still more dangerous kind.

Theorem 2.—*Mercury disintegrates or decomposes the blood, and thus wastes the body.*—This is the systemic action of mercury, on which too much stress cannot possibly be laid. Dr. Wright has analyzed the blood of patients under mercurial action. It is materially changed. It contains more water, and is more prone to putrefaction, than healthy blood. The fibrine, albumen, and red globules, are diminished in amount, and a very fetid fatty matter is present in large quantity. The following is an average of three analyses of blood from men under mercurial influence:—Water, 827·6; fibrine, 2·4; albumen, 57·2; red globules, 94·5; oil, 4·1; fetid fat, soluble in ether, 9·5; salts, 3·7; loss, 5·1=1000. Mr. Smith has observed that the blood coagulates with difficulty. When coagulated, it is cupped and buffed; but it is the buffy coat of anæmia, and not of inflammatory blood; the clot appears rotten, and is easily broken down.

The mercurial, then, by some inscrutable chemical power, of whose nature we know nothing, is able to decompose the blood; by some destructive agency, it deprives it of one-third of its fibrine, one-seventh of its albumen, one-sixth or more of its globules, and at the same time loads it with a fetid matter, the product of decomposition. Such power is possessed by few other medicines, and certainly exerted by none in the same degree as by mercury. It is an agent of terrible activity, and we may well be cautious how we handle it.

By this artificial disease that it produces, it may cause, when pushed to excess, various constitutional disorders of a very serious kind. As agents which impoverish the blood drive it to the tissues for its replenishment, and thus give work for the absorbents, so mercury wastes the frame, causes the body to become thin and feeble, the face pallid, and diminishes the nervous energy. It may also excite the febrile or typhoid condition called "mercurial erethism," or a disease of the skin of a squamous or eczematous character, as the "hydrargyria," described by Alley in 1804. To remedy these disorders, which are produced by retention of mercury in the blood, we should employ eliminatives, especially saline purges. During the action of mercury, the system is, as it were, disarmed, and thus more exposed to the action of various irritating causes, as cold, which produce a low kind of inflammation, especially of the mucous surfaces. The patient must for this reason be kept warm and quiet during its operation.

Theorem 3.—*Mercury is ultimately excreted. It passes out by some glands more than by others, increasing secretion, both healthy and morbid.*—Small as may be the amount of the metal absorbed, it is an active poison while in the blood. It cannot remain there—the system strives to reject it; it is accordingly excreted, still in a soluble form, by means of various glands. A necessary condition of its excretion is, that it should be dissolved by the fluid which passes through the glandular apparatus. Mercury, as it exists in the blood, appears to be soluble to some extent in most of the natural secretions. While passing into them, it increases their amount, according to the general rule of eliminative medicines. It is cathartic; it has been detected in the fæcal evacuation after rubbing in mercurial ointment. It is cholagogue, and has been discovered in the bile of dogs to which it had been administered, by Buchheim. It is diuretic, and has been found in the urine, in spite of the notion of Murray that the phosphoric acid in that secretion is incompatible with it. It increases the secretion of the skin; and on administering a course of sulphur after one of mercury, black sulphuret of mercury has formed on the surface of the body. It increases the saliva, but does not do this until a considerable amount has become collected in the blood. When the skin cannot carry off the poison in sufficient quantity—when the solvent power of the urine is exhausted—when the bowel is prevented by opium from eliminating the mercury, then, as a last resource, the salivary glands step in, and in the saliva the metal finds an exit. This symptom, therefore, on the terrible development of which that may result from the over-administration of mercury I will not now enlarge—this symptom is a sign that the constitution is saturated with the remedy, and any great increase in the degree of salivation should warn us to discontinue it. For it is to be observed that the salivation is not intended to cure the system of the previous disease, but simply to cure the system of the mercury. The metal has been found in the saliva by Lehmann.

When given in small amount, the mercury acts most on the secretions of the liver and the intestinal canal. The reason why it acts upon the latter is simple. Mercury not only augments healthy, but causes morbid secretion. The nitrogenous elements of the blood which it destroys cannot remain in the system, any more than the mercury itself. Decomposing matter is a poison in the body of a living animal. To the intestinal glands is ordinarily allotted the function of evacuating matters in a state of active decomposition. These are increased in amount by the exhibition of mercury. Even from a small dose of this the fæces acquire a peculiarly graveolent and altogether unnatural character, and contain considerable quantities of sulphuretted hydrogen gas and hydrosulphate of ammonia,—ultimate products of organic decomposition, which are said by Liebig to be undiscoverable in healthy fæces. These substances doubtless result from the action of mercury on the blood, into which it has passed from the upper or absorbent portion of the bowel, and from which it is evacuated in their company by means of the lower or eliminating portion—the ileum and large intestine. But when the intestinal secretion is repressed by opium, or more work is thrown on the bowel than it can perform, these noxious matters, too, pass into the saliva, and add a most nauseous savour to the metallic taste of the mercury.

Children and old persons are both salivated with difficulty. Dr. Graves ascribes this to the non-development of the parotid glands in the former, and their shrunken state in the latter. Mialhe attributes it to the deficiency of chlorides in their secretions, and states that they can easily be brought under the influence of mercury if corrosive sublimate be administered instead of calomel.

We have next to consider the therapeutic operations of Mercury. It is Hæmatic and Eliminative.

1. As Hæmatic medicines, Mercurials have a double action. They counteract inflammation in general, and the poison of Syphilis in particular. They thus belong to the first and second orders of Catalytics. Mercury is Antiphlogistic and Antisyphilitic.

Mercury deteriorates the blood, diminishing in it the amount of fibrine and corpuscles. As an anti-inflammatory agent, it may be thus compared with Antimony and Blood-letting. The immediate effect of Blood-letting is mechanical; that of Antimony, nervous; that of Mercury, hæmatic. Blood-letting weakens the force of the heart by diminishing the pressure on the vessels; Antimony diminishes the pressure on the vessels by weakening the force of the heart; and

Mercury does both of these things by impoverishing the blood. Thus all of them favour absorption, and counteract effusion; but, from its nature, the action of Mercury is slower than that of the others, and for the same reason more lasting. To produce this action on the blood, the Mercurial should be continued until some effect on the mouth is perceived, but not so as to cause copious salivation. This symptom is a sign that the blood is sufficiently saturated with the medicine. This point will be sooner reached if the Mercury be conjoined with Opium,* so as to prevent it from passing out directly by the bowels. Any ill result is less likely to occur if the patient be kept warm and quiet while under the influence of the medicine. On account of the durable and effectual nature of its action, Mercury is of great use in preventing the process of effusion, and in causing the absorption of effused products. It is thus employed with advantage in Pleurisy, and in other membranous inflammations. Next to these, it is most useful in inflammations of the liver and brain. It is inferior to Antimony in fevers and rapid inflammations, because slower in operation, and without any direct action on the nervous system. Antimony arrests inflammation by reducing the pulse; Mercury reduces the pulse by arresting inflammation.

In cases of primary Syphilis, Mercury is by far the best medicine with which we are acquainted. It is generally used in all cases except where there is deep-rooted scrofula, or marked debility, or a sloughing and irregular condition of the primary sore. (*Dr. Pereira.*) It should always be given in Iritis. In Periostitis, and secondary eruptions, Iodide of Potassium is generally preferable.

In dividing under three chief heads the cases of syphilis which may occur in a constitution not previously under the influence of the poison,

* But the combination of Mercury with Opium should not be persevered in to too great an extent. By preventing the passage of the metal by the bowels, it causes it to determine to the salivary glands. By this excessive and dangerous salivation, exfoliation of the jaw, etc., may be produced.

I am only expressing a view of the subject which I believe to be common at the present day.

A fresh sore results from venereal infection. During four to five days the inoculated poison must work in the tissues about the surface of this sore, before it can be sufficiently elaborated to affect the general system through the blood. If, during this time, the sore sloughs, then the poison is destroyed and sloughed away before it is ripe. If we produce this effect by caustics, being sure that we are in time, the same occurs. Then we need not, I think, administer mercury.

In a second class of cases the sore ulcerates. Its edges are rough and jagged. It has not sloughed away; but the poison, having ripened, has passed along the absorbents to the glands in the groin. These swell and suppurate, and with the pus the poison is discharged: it does not further affect the system. In such a case, we need not, I think, administer mercury.

In the third case, the inflammation on the surface of the sore is of the adhesive kind. The edges are raised, the surface is somewhat cupped. The whole has a horny feel. There is little irritation; no sloughing. It is the chancre of Hunter and Carmichael, more or less marked. We will suppose that the period of ripening has passed. The poison now infects the blood; it does not stop at the glands or inflame them. It passes straight into the system at large, and a rash declares that the constitution is affected. When a chancre of this kind is destroyed by nitric acid, or some other caustic, then all may go well; but when it has had time to mature, then, I think, we *should* administer mercury. We must introduce the only medicine of which we are thoroughly convinced that it possesses the power of efficiently striving with the enemy who by subtle means has now effected an entrance within our stronghold.

The blood-operation of Mercury, by which it is enabled to counteract morbid processes, is involved in considerable obscurity. The same must be said of all Catalytic medicines. Dr. Billing (*Principles of Medicine*, p. 73) is of opinion that Mercury acts by contracting the capillary vessels. I have already stated my reasons for dissenting from this notion (p. 198.) The same author denies the specific action of Mercury in Syphilis. But if we only admit that there is no other medicine that will cure primary Syphilis so well as Mercury, we cannot then surely deny that its action in that disorder is of a special nature. He considers it to be neither stimulant nor sedative,—but tonic. (*Op. cit.* p. 101.) No one of these terms appears to me to be strictly applicable, but perhaps the last is the best of the three.

A perfect host of theories have at various times been brought forward as to the special action of mercury in syphilis, and its influence over other disorders. When first proposed by Paracelsus and the chemic school, it was considered that mercury acted by supplying a component part to the human body. The disciples of this man were told that the body itself consisted of salt, sulphur, and mercury; that any of these three, when in relative excess, was capable of causing disease. Mercury, being volatile, produced tremors, mortifications, madness, and delirium. Sulphur caused fevers and phlegmons. Salt generated stone, gravel, gout, and colic. A deficiency in mercury being the cause of syphilis, was one reason why the remedy was given to counteract it.

The first exposition of the mechanical theory of the action of mercury, commonly attributed to Boerhaave, and which held its ground for so long a time after him, is to be found, as far as I know, in the treatise, "De Mercurio," of Joh. Dettinger, in 1658. He ascribed the effects of mercury to the penetrative power possessed by its globules. "Occurrunt in argento vivo vis penetrativa, separativa, et mundificativa, tam in metallis quam in animalibus, unde istâ non solum corpora maxime dura penetrat, sed etiam per os exhibitum nonnunquam αδηλως και αναισθητως carnem penetrâsse, perque exterioris corporis meatus rursus excipisse," (p. 8.) The notion of Boerhaave was of a more subtle kind. "If mercury," he said, "is mixed with other liquids, and a motion impressed on both of them from the same cause, the mercury will be carried much more swiftly, and will keep its motion longer than the other liquids, wherefore its particles impinging on the less moved particles of the fluids, will penetrate, divide, and comminute them by a certain force arising from the excess of its velocity, and will impress a greater motion upon them." He supposed that in this manner the lymph collecting in the smaller vessels was broken up and dispersed. Drs. Pitcairn, Perry, and Mead, in England, adopted a similar notion, supposing that the particles of matter which constituted disease were broken by the weight and friction of the heavy globules of mercury. The determination of mercury towards the salivary glands was also mechanically explained. The impetus given to the weighty metal by the action of the heart was so great that it was carried along the carotids upwards in the direction of those glands rather than to other parts of the body. Another mechanical notion which came nearer to the truth was, that mercury in transuding outwards through the pores of the skin, eliminated the venereal poison by pushing it before it. Vincent Brest conceived that this metal entangled and absorbed the syphilitic virus in much the same manner as a sponge does water.

At a later period, when the mechanical school had declined, and the theories of Sydenham and the humoralists came into vogue, it was supposed by many that the poison was cast out of the system by means of the salivary secretion. This mistake coupled with the overlooking of other means of elimination, led to the most fatal errors in practice. A symptom at all times inconvenient, and which should act as a warning of the complete saturation of the system with mercury, was pushed to an extent which became dangerous, or even destructive.

The theory of the cure of syphilis propounded by John Hunter, and maintained by many since his time, is, that two poisons cannot work in the system at the same time; so that when the poison of mercury has its way, the poison of syphilis must yield. Now, this theory is obviously most unreasonable. Without pausing to argue that two morbid poisons may really co-exist in the system—a fact which is now admitted by all pathologists—we may simply ask, whether mercury, an active agent from without, is a poison in the same sense as syphilis? If so, then arsenic and opium are so also. But cannot a man who is under the influence of mercury be poisoned by arsenic or by opium? Most assuredly he can. Then two poisons can exist in the system at the same time.

Many writers at the present day speak of mercury as a specific, and seem to consider that it neutralizes syphilis much in the same way as an acid does an alkali. Indeed, this very comparison has been applied to the case. But it cannot be appropriate except in an extremely metaphorical sense. As an expression of anything in the shape of a fact—as we know nothing of the nature of the poison of syphilis—it must be worthless. With an acid and an alkali the neutralization is mutual; but if mercury neutralizes syphilis, it is certain that syphilis does not neutralize mercury. The metal is a poison while it remains in the system, and must leave it before health can be re-established. The parallel therefore fails. In a strict sense, it is probable that no morbid poison can be neutralized. It may be destroyed, or got rid of by evacuation.

It is clear that Mercury has the power of destroying or counteracting the lethal influence of certain blood-poisons, especially that of Syphilis. We have also seen that this metal in some manner destroys a part of the solids of the blood, and eliminates them from the system in an altered or decomposed form. Now Syphilis itself also decomposes and deteriorates the blood. It seems to me that the only way in which we can give a consistent explanation which shall dovetail and reconcile these various phenomena, is to suppose that the metallic agent, when given in Syphilis, first of all exerts its destructive energy upon the infected particles of the blood, which may be supposed to be already prone to decomposition. Like the caustic which destroys the tissue that has been bitten by a rabid dog, and prevents the fermentation of the virus which would else result in Hydrophobia and death,—but in a far less obvious manner,—the Mercury may assail the syphilitic poison, and the parts of the blood upon which it has exerted its action, and by destroying them and it together, and sweeping them away in company with itself by the glandular outlets of the body, may prevent any further working of this morbific element on the system. (*Vide* p. 219.)

2. Mercury, being unnatural to the blood, passes at length out of the system through the glands, and acts as an Eliminative. Like Antimony, it tends to increase all the secretions in the body. But whereas Antimony acts especially on the secretions of the skin and pulmonary membrane, Mercury tends particularly to excite the functions of the liver and bowels, being Cathartic and Cholagogue. When its action has proceeded to such a point that the system is thoroughly infected with it, it acts as a Sialagogue. Of its true eliminative action we have better proof than has yet been obtained in the case of Antimony; for Mercury has been found to pass into the alvine excretions, and into the saliva, by M. Lehmann; and discovered in the bile of dogs to which it had been administered, by M. Buchheim.

For the purpose of acting upon the liver and bowels, Mercurials are frequently used in disordered digestion and cases of hepatic derangement. In Intermittent disorders, Debility, Gout, Rheumatism, and Scrofula, small doses of Mercury are often of service. I have endeavoured to show (p. 177) that in these cases they may prove indirectly tonic, by restoring to the system some of the wanting elements of bile, which are normally secreted by the liver for the purpose of being re-absorbed into the system. In such cases we must by no means combine it with opium. This combination may be suitable in some peculiar cases of local inflammation; but it often hinders the proper action of Mercury instead of promoting it, and checks the elimination which is attended with such advantage.

In incipient and chronic cases of Scrofula, consumption, and mesenteric disease, it is possible that Mercurials may act yet in another way. They no doubt stimulate the formation of the Pancreatic secretion, which is similar in nature to the saliva. By doing so they may assist the absorption of the fatty matters of the food in the case of thin and emaciated subjects, in whom it is probable that the function of this gland is frequently impaired. (*Vide* p. 377.)

Mercury assists the operation of all other medicines which act upon the secretions. In cases of hepatic dropsy it helps the action of Diuretics, and tends to remove the cause of the congestion, by stimulating the function of the liver.

Some have, without sufficient reason, assumed Calomel to be a Sedative when given in large doses. To act in this way, very large doses have been recommended and given in fever and malignant cholera. Calomel is naturally an insoluble substance; and in these cases the function of absorption is at the very lowest ebb; so that it is probable that the large doses are often left unabsorbed, and pass out of the bowels very much as they entered, producing scarcely any more effect than so much chalk mixture.

Were we to believe all that has been said about this drug, we should welcome in it a cure for all the ills that afflict humanity, the veritable panacea of the old dreamers. Unfortunately we cannot do this. But it is an agent of wondrous properties, a remedy of vast and varied power; perhaps, altogether, the most useful in our Pharmacopœia. It is the very prince of that class of remedies, unfortunately too few, that are capable of entering the system, of grappling with a disease in the blood, and of coming off victorious in the struggle.

Putting aside for the moment its use in the phlegmasiæ and in chronic disease, were it only for its power in syphilis, it would be of the utmost value to us. The syphilitic poison is connected in some manner or other with about half the diseases of towns. Is it likely to die out? Fordyce, on being asked this question, replied with another—Are men becoming tired in the pursuit of pleasure? The great moral ulcer of our social system, in spite of all the efforts of philanthropists and legislatures, is hardly likely to be healed so long as men continue in their present state of mind.

> "Audax omnia perpeti
> Gens humana ruit per vetitum nefas."

Moreover, it is said, and I think with a fair show of reason, that syphilis is even gaining upon us in London. Is it wise then to do what some would advise, to let the only valuable weapon with which we are armed against it drop through our fingers? The more we know of its real actions, of the mystic processes of its absorption and operation on the system, and of the comparative physiological tendencies of the various forms in which it is administered, the better shall we be able to wield it with skill and effect. In a line of investigation and of patient experiment on disease and remedy lies our best and wisest course; and so long as we steadfastly pursue this widening path, so long at least we physicians can say, that at the bottom of our box of Pandora there lies a Hope which is not yet flown.

IODINE.

Class I. Div. II. Ord. II. ANTISYPHILITICA.
Class I. Div. II. Ord. III. ANTISCROFULOSA.

The readiest and best way of obtaining the beneficial effects of Iodine is by the use of Iodide of Potassium. This is a very soluble salt. The peculiar virtues of Iodine are not impaired, but rather improved, by its chemical combination with the alkali. And when we administer the Iodine itself, as in the tincture, there is no doubt that after entry into the blood it combines with some alkaline base.

In thus combining with an alkali,—suppose it to be Soda,—it forms an Iodide of Sodium, along with an Iodate of Soda. Thus we have something more than an Iodide. The Iodate is more irritant, and is apt to produce gastric pains. These may be caused by the commercial Iodide of Potassium, when, as is frequently the case, that salt contains an Iodate of Potash. (*Leroy.*)

If the use of Iodine be continued for some time, it has the effect of impoverishing the blood. It sometimes produces a vesicular eruption on the skin, and causes a considerable degree of irritation of the mucous membrane of the nose and eyes,—with some fever.

The preparations of Iodine exert in the blood some special actions of a Catalytic kind, by virtue of which they are enabled to counteract the morbid actions of secondary Syphilis and of Scrofula. Iodine is not, like Mercury, a general Antiphlogistic; but it is a stimulator of the function of absorption, as are all the medicines that tend to impoverish the blood. Such medicines, when their action is pushed to an extreme, may, by destroying the albumen and fibrine of the blood,* cause it to repair for its renovation, by means of the absorbent system, to the very tissues themselves. This action, in causing absorption, can be no explanation of the blood-operations for which Iodine is employed; for these are peculiar to it alone; whereas the other property is shared by other remedies. But this absorbefacient action has doubtless been much exaggerated. By its action in neutralizing poisons in the blood it is able to disperse any tumours that have a scrofulous or syphilitic origin. But it has been used to cause the disappearance of growths that have no such origin,—and with very indifferent or negative success. Mr. Fergusson states that he has never in one single instance seen an organized adventitious growth removed by its means. (*Manual of Practical Surgery*, p. 169.) I doubt myself whether Iodine could possibly cause the absorption of any swelling unconnected with these cachexies, or of any gland or part in a healthy state, without at the same time bringing the patient to death's door by the impoverishment of the blood which it must produce.

Iodine is an Antisyphilitic. But this term is not appli-

* "Iodine is one of the most energetic of the class of Fluidifiants."—*Mialhe.*

cable to it in exactly the same sense as to Mercury. Its use is confined to the later symptoms,—to Periostitis; and the late eruptions, as Rupia. Sometimes it even fails in these. This is generally when the primary disorder has not been met by Mercury. Some preparation of Mercury should then be administered for awhile; and the Iodide of Potassium may be given afterwards. Thus the disorder which is controlled by the latter medicine is so modified as to be something quite distinct from the primary Syphilis. The great discovery of the use of the compounds of Iodine in secondary Syphilis was made by Dr. Williams, and announced by him in a paper read before the College of Physicians in 1834.

The same medicine is an Antiscrofulic. It is applicable in all the forms of Scrofula, and in Goitre. Possibly it acts differently in such cases; but it is certain that there is often, in cases of confirmed Syphilis, a cachexy similar to that produced by Scrofula. In either disorder, when this cachexy is confirmed, Mercury is most objectionable. On the contrary, in primary Syphilis, and even in incipient Scrofula, Mercury may be used.

As Iodine is a cure for Goitre, some have ascribed this affection to the use of water which does not contain Iodine. But I do not think there is any ground for this idea. This unpleasant deformity is common in some South districts of England, in the immediate neighbourhood of the water of the ocean. Rain-water has been found by recent analyses to contain Iodine, and there are but few springs and rivers which are not partly supplied from this source. The Goitre and Cretinism of the Alps is vulgarly ascribed to the drinking of *snow water* distilling from the glaciers. Some find fault with its coldness. Some object to it that it does not contain Iodine. This is to be doubted; but, if true, it would probably be a matter of no importance. On the other hand, the old physicians, as Dr. Mead in 1702, alleged a superabundance of calcareous salts in this water. A simple observation of such matters as pass before the eyes of every tourist is sufficient to demonstrate that the *snow water* is noways in fault. In the upper and more airy part of the valley of the Rhone, I observed that scarce any of the inhabitants were afflicted with Goitre or Cretinism; but they are the nearest to the great glacier from which the river takes its rise. Far away from this, at Martigny, at the lower part of the same valley, these diseases abound; so do they in the beautiful Val D'Aosta; but these situations are confined and low, and penetrated by no direct current of air, on account of the mountains by which they are surrounded on all sides. The contrary being the case at Chamouni, the inhabitants of that village are healthy; for though living at the foot of Mont Blanc, and deriving their water from the melting of its glaciers, their situation is airy and salubrious.

Like all potent remedies, Iodine requires to be carefully used. It is sufficient to give it in small doses. If given in large doses, and too long continued, it causes a deterioration of the blood, followed by an emaciation of the whole frame. So vigorously was this medicine used by the Swiss practitioners after its first discovery, that serious consequences, as the absorption of the mammæ or the testes of healthy individuals, are said to have ensued in several cases. By these mishaps their faith in its utility was much shaken. But M. Magendie states that he has never known such a thing to occur; and M. Lugol, the most devoted and enthusiastic of all the advocates of Iodine, has observed that scrofulous patients frequently become fattened during its employment. In fact, such results as those above stated can only take place when the remedy is unwisely and most incautiously employed.

The therapeutic actions of Iodine have been ascribed by Dr. Billing to a contraction of the capillary vessels; by Dr. Pereira, to a liquefaction of the blood; by others, to a direct stimulation of the absorbent system. It probably counteracts morbid operations in some way that we do not understand. It is one of those medicines which tend to increase secretion in general. It appears to act most upon the urine, but is not a powerful Eliminative. It has been chemically discovered in the blood, urine, and sweat; as also in the saliva, tears, and nasal mucus, which secretions are apt to be increased in quantity during its action.

The Iolide of Potassium should be cautiously administered to excitable patients, as it sometimes acts as an irritant. When the stomach is irritable, it should be given after meals, and the dose considerably diluted with water.

A bronchoçele, to be benefited by Iodine, should consist of a simple enlargement of the gland, not of very long standing, nor painful to the touch. All scrofulous affections, whether of the glands, joints, liver, or other parts, are more or less benefited by the use of Iodine. Iodine has been used in simple enlargement and induration of various organs, particularly the uterus. Dr. A. T. Thomson speaks highly of its efficacy in ovarian dropsy. But, as I have just stated, it is my opinion that in cases unconnected with Scrofula or Syphilis we can place little or no reliance on this medicine.

It is probable that Chlorine, Bromine, and their compounds, closely resemble the preparations of Iodine in their therapeutic operations.

COLCHICUM.

Class I. Div. II. Ord. IV. ANTIARTHRITICA.
Class II. Div. III. Ord. I. SEDANTIA GENERALIA.
Class IV. Ord. III. CATHARTICA.

The majority of medicines that affect the blood permanently belong to the mineral kingdom, while most of those that powerfully impress the nerves are derived from vegetables. But to the rule that Hæmatic medicines are of mineral origin, we have already found one important exception in the case of Quinine and Tonics. Colchicum appears to be another instance of the kind. The great and obvious use of this remedy is that action in the blood which above is classed first, *i. e.* its influence in the counteraction of gouty disorders. We have already considered at some length (p. 235) a number of Antiarthritic medicines that seem to act in a chemical manner. Colchicum is not one of these. It is a General Sedative, and a Cathartic; in large doses, an irritant poison. It seems also to increase the amount of other secretions, particularly the urine and the bile. But it is used beneficially in Gout; and it is assumed that in the cure of this disorder it exerts an action in the blood, inasmuch as its remedial operation appears to be independent of its nervous and glandular actions. This hæmatic action must be of the Catalytic kind, and may probably consist in the exertion of a special influence over the erring assimilative processes, which tends to resolve them into a right direction.

But it should be observed that at least three other explanations of the action of this remedy have been proposed, each of which is possessed of a degree of plausibility.

Some have ascribed its efficacy to the union of a cathartic with a sedative effect, and have even substituted for it a combination of Opium with a drastic purgative. Those who adopt this view of its action aver that Colchicum acts best when it purges freely. But though Purgatives are often of use in gouty disorders, it is generally found that Colchicum operates most favourably when given in too small a dose to produce any purging.

Colchicum stimulates the function of the liver, which is generally deranged in gouty disorders. Mercury, which also promotes the secretion of bile, is in this way useful in Gout. It seems that the formation of this secretion is in some manner essential to the integrity of those blood-processes which are disturbed in arthritic diseases. It might therefore be supposed that Colchicum too acted as a Cholagogue. But it is not clear that it increases the secretion of bile in any very marked degree.

Thirdly, it is affirmed by some that this medicine is of use in eliminating uric acid from the blood, this product being supposed to accumulate in the system before the paroxysm of Gout. It is said that under the action of Colchicum the natural amount of this substance in the urine is much increased. This would be an important fact if it were certainly proved. But it does not seem to be so; indeed it would seem that the phenomenon referred to, in the cases where it was observed, must have been a symptom of the disorder, rather than of the treatment.*

Colchicum is more or less applicable in the gouty forms of Rheumatism, in Lithiasis, and in acid dyspepsia, but it is most efficient in the simple gouty paroxysm.

There are several objections to the indiscriminate use of this remedy. Some have observed that though it cures for a time the gouty attack, it causes the next assault of the disease to recur more quickly than it would otherwise have done. The dose also certainly requires to be considerably increased on each successive occasion. Sometimes this medicine produces a great depression of the spirits. Dr. Todd believes that Colchicum has often a tendency to change the common acute form of Gout into an asthenic form which is less amenable to treatment. So that, altogether, it is perhaps a good rule to treat the patient without Colchicum as long as it can be done with safety, adopting this medicine only as a last resource, when other remedies have been tried and failed.

It ought rarely to be used in Rheumatism. In the asthenic

* This statement of the augmented excretion of Uric acid was made by Chelius of Heidelberg. It was disputed by Dr. Graves of Dublin; and Dr. Pereira not only denied it, but thought it likely that Colchicum would rather diminish than increase this excretion. (*Materia Medica*, 3rd edition, p. 1051.) The original statement, though probably an error, has been repeated by many as by Dr. Paris. (*Pharmacologia*, 9th edit. p. 342.) Dr. Maclagan states that, Colchicum also increases the elimination of Urea,—a statement that will perhaps share the same fate as the preceding. But on this ground he recommends it for use in Bright's disease. (*Monthly Journal*, Jan. 1852, p. 30.) It has already been given in dropsy by Störck: seeming to act as a purgative and diuretic.

form of Gout, or in old chronic cases, when there are chalk-stones on the knuckles, Quinine, Stimulants, and Purgatives constitute the best treatment. Alkalies, and Mercurials, may prove serviceable in acute cases.

But it is certain that in many cases of this painful disorder Colchicum gives immense relief; and it often seems to be the only medicine that is capable of doing so.

ARSENIC.

Class I. Div. II. Ord. VI. ANTIPERIODICA.
Class I. Div. II. Ord. VII. ANTICONVULSIVA.
Class I. Div. II. Ord. VIII. ANTISQUAMOSA.

This medicine has already been noticed at considerable length in the account of the last three orders of Catalytic medicines. It is again noticed here as one of the most remarkable of those mineral substances that are used to counteract blood-disorders. It appears to be capable of exerting no less than three kinds of action in the blood, which operations result in the counteraction of Periodic disorders, Convulsive diseases, and certain cutaneous eruptions. That must of necessity be a various and obscure agency, which is gifted with the power of arresting and controlling so great a variety of morbid actions.

We can give no certain explanation of its action, and can only suppose that, like Mercury with others, it probably decomposes these poisons, and causes them to be eliminated from the system.

It would seem that Ague and its kindred disorders are capable of being combated and cured in two different ways; by Restoratives, such as Quina, which appear to supply the blood with a certain needful material; or by Catalytics, as Arsenious acid, which operate by antagonizing a morbid action which is either the cause or the result of the blood-disease. I have given my reasons for ranking Quina and Tonics among Restorative medicines. The following are the principal grounds for which Arsenic is included among Catalytics. It is unnatural to the blood, and is at length excreted from the system. It acts as a poison;* and is able to work out in the blood a certain process of its own. It has no sudden action on the nervous system, like that which is possessed by Neurotic medicines. And it is able to counteract a number of disorders, as Lepra and Impetigo, which are assumed to depend upon morbid actions in the blood.

Arsenic has been recommended in Syphilis, but it exerts no marked power over that disorder. In Ague it possesses this advantage over Quina, that it may be administered with safety during the paroxysm. The ordinary precautions in the administration of the Arsenical solution (Liquor Potassæ Arsenitis) have been already enumerated, viz.: that the dose should be small at first, and afterwards gradually increased; that as soon as it produces swelling of the face and eyelids, or irritation of the stomach, it should be discontinued, or the dose reduced; and that it should generally be given on a full stomach, as it is then less likely to irritate.

AMMONIA.

Class I. Div. I. Ord. III. Alkalia.
Class II. Div. I. Ord. I. Stimulantia Generalia.
Class IV. Ord. II. Expectorantia.
Class IV. Ord. V. Diaphoretica.

This medicine may be taken as the type of simple General Stimulants. It tends to excite the nervous forces generally.

* The statement has been made in various works, that Arsenic may be consumed in considerable quantities with impunity by those habituated to it; and that it is actually eaten by the peasantry in Lower Styria for the purpose of improving their complexion. (*Johnston's 'Chemistry of Common Life,'* etc.) There is no proof that such a toleration is possible with any of the metallic poisons. The only foundation for these astonishing statements would seem to be that men and women dwelling in aguish districts may take Arsenic in small doses with advantage.

The remedies of this group are not very potent in their action, Ammonia being perhaps as powerful as any of them. Alcohol, an Inebriant Narcotic, produces at first a greater stimulant effect, but its action is followed up by a depression of the nervous forces, and an affection of the powers of the mind. This influence over the intellectual functions is confined to the Narcotic division of nerve-medicines, and is not possessed by Ammonia.

Ammonia is capable of acting chemically as an alkali in the system, and may be used in various cases in which alkalies are wont to be employed; but it is inferior to Potash in such disorders, because its affinities are far less powerful than those of that alkali. It is also caustic and irritant when applied externally in any form.

Dr. B. Jones has stated that when given in large doses Ammonia undergoes an oxidation in the system, by which some Nitric acid is produced. But the statement has been since called into question by Lehmann and Jaffé, the latter of whom has repeated Dr. Jones' experiments, but arrived at a contrary result. (*Journ. für Prakt. Chem.* June, 1853.)

According to Dr. B. W. Richardson, the existence of free Ammonia in small quantity in healthy blood is the chief or only cause of its alkaline reaction. To the escape of this volatile alkali after blood is drawn, and the consequent liberation of the fibrine which it held in solution, Dr. Richardson ascribes the phenomenon of the spontaneous coagulation of blood.*

Administered internally in solution, Ammonia has a power of quickening the action of the heart, and exciting the circu-

* *Astley Cooper Prize Essay, On the Coagulation of the Blood*, 1858. Another way of plausibly accounting for this phenomenon had been previously suggested by myself. Small quantities of Glucose exist in the blood. The slight degree of fermentation or putrescence that would ensue after the blood is drawn. might cause this Glucose to develop into Lactic acid. This would then neutralize the alkali present, and set free the Fibrine.

lation generally. It is therefore particularly useful in the common case of Fainting, or threatened Syncope. This stimulant power is possessed only by the free alkali and its carbonates. And as the secretion of the stomach is acid, Dr. Pereira supposes that the free or carbonated Ammonia becomes neutralized before absorption; that it is therefore unable to act in the blood except as a salt, and can only operate as a Stimulant while in contact with the coat of the stomach. Its influence must then be conducted by the nerves from the surface of the stomach to the heart. But though the nerves are the natural channels of various motor and sensory impressions, it is to assume an unprecedented thing to suppose that a medicinal action can be transmitted by their means to a distant part. For this and for other reasons it seems to me to be most likely that the solution of Ammonia is absorbed too fast in the stomach to be neutralized by the gastric juice. Or even if it were neutralized before absorption, it would probably be again set free on entrance into the blood, in which there is a slight excess of alkaline matter. Thus Ammonia would exist in the blood in a free state, except in those morbid conditions in which there is a general excess of acid in the system. I suppose the same to be the case with Potash, when it is given in any quantity. The great diffusibility of the free Ammonia would be an additional reason for its rapid absorption. When the gas is inhaled, as in the use of smelling-salts, and applied thus to the nasal and pulmonary mucous membranes, it must pass through to the blood in a free state, for these surfaces do not secrete an acid. And yet its effects in this case are the same as when it is taken into the stomach, which further renders it probable that in the latter instance it is absorbed free.

When there is an excess of acid in the system, Ammonia may be used as a Restorative. It diminishes the acid reaction of the secretions by combining with the acid to form a salt.

In ordinary conditions, (*i. e.* when not required in the system) it has to be excreted from the blood. Both Ammonia and its salts act as Expectorants and Diaphoretics, being excreted on the mucous surface of the lungs, and on the skin. Free Ammonia is a better Expectorant than any of its neutral salts. The secretion of sweat contains an acid. The Ammonia which passes out on the skin combines with this acid. But on the pulmonary surface it is probably excreted free. For it is found that the careful inhalation of Ammoniacal gas has the same effect in augmenting the mucous secretion as the internal use of Ammonia. Ammonia is volatile, and soluble in air; and tends for that reason to pass off freely from those secreting surfaces which are immediately in contact with the atmosphere. (p. 334.)

Experimenters differ on the question of the presence of Ammonia in the breath and perspiration. The former is more readily examined. Richardson (*op. cit.,*) with Viale and Latini, states that Ammonia is present in the healthy breath. Reuling, on the contrary, finds that the Ammonia in the expired air amounts only to one-eighth of the quantity in the air inspired. (*Inaugural Dissertation, Giessen,* 1854.) But this Ammonia in the breath, an index of that in the blood, is increased, he says, in low Fevers and Albuminuria, though not in Catarrh, or chronic blood diseases. In the latter cases only is it admissible when given as an Alkali, or advisable for any length of time as a Stimulant.

It is supposed by some that diffusible Stimulants act simply on the ganglionic system of nerves, being able through them to excite the functions of the heart, vessels, and glands. But Ammonia is used with advantage in some cases in which the whole nervous system is implicated in the disorder. It has been employed in cases of Typhus, of simple febrile exhaustion, of Hysteria, and Epilepsy. In such affections the brain is at least involved, if not often the chief seat of the disorder.

Ammonia is applicable in all cases where general stimulants are indicated, and an alkali is not undesirable. The Carbonate, in large doses, has been given with great success in various depressing disorders, as Scarlatina maligna (Mr. Wilkinson) and Equinia (Dr. Mackenzie.)

Spasms and convulsions are due to a general derangement of the nervous forces, and particularly of the brain, in which these centre and originate. Stimulants, by exalting the natural functions, counteract and control this derangement. It is thus that Ammonia and volatile oils are of use in convulsive disorders; but they are seldom of any permanent efficacy, as in most cases of Hysteria and Epilepsy there is at the bottom a blood-disease, of which the spasmodic fits are only the symptom and outbreak. (*Vide* p. 253.) So also is there a limit to the efficiency of Stimulants in such cases as Typhus fever; there is a certain point of exhaustion beyond which they are of no avail. For I have attempted to show that though Stimulants are competent to exalt nervous force, they are unable to supply vital force. A degree of nervous force is necessary to the continuance of life; but when the powers of life themselves are ebbing away, it is impossible then to prolong any further the thread of existence by the exhibition of Stimulant medicines.

It may further be observed that the fact, if established, of the increased excretion of Ammonia, by the breath and skin, in low fevers and eruptive disorders, is by itself a contra-indication to the employment of the agent, because showing that there is already too much of this alkali in the system.

The action of Ammonia is directly the reverse of that of Prussic acid, which is a General Sedative, producing Convulsions and Syncope. Ammonia is thus used in cases of poisoning by that liquid.

STRYCHNIA.

Class II. Div. I. Ord. II. Stimulantia Specifica.

Strychnia is the chief alkaloid and active principle of Nux Vomica.* This medicine is comparatively simple in its action. It has no claim to the title of Sedative, which is sometimes applied to it. It does not affect the nerves generally. It has no direct action on the brain, but stimulates chiefly the function of the spinal cord, and its system of nerves. Of these nerves it affects the motor considerably more than the sensory branches. Along with the spinal cord, it doubtless also acts upon that part of the brain which is immediately associated with the spinal system of nerves. But the function of reflex motion, which is thought to reside in the spinal cord, is particularly stimulated.

Strychnia is thus an exciter of muscular contraction and of motion; exalting sensation in a less degree. That it operates by an action on nerve, and not on muscle directly, has been proved by the experiments of Matteucci. It has also apparently some action on a part of the ganglionic system of nerves, by which it is enabled to promote the function of the stomach, and becomes temporarily a tonic when given in relaxed conditions of that organ. But it does not excite the action of the heart.

In cases of poisoning by Nux Vomica, the brain and the heart are unaffected. Tetanic and general convulsions are produced; and the immediate cause of death is a spasm of the muscles of respiration.

Dr. Taylor has very clearly laid down the distinctions between the kind of Tetanus which is produced by Strychnia, and that which is the result of disease. The symptoms are sudden and violent, nearly all the

* According to Professor Taylor, Nux Vomica contains half a grain per cent. of this alkaloid. According to Mr. Horsley (*Chemist*, iv. 2) as much as 1 per cent.

voluntary muscles are affected simultaneously. Opisthotonos occurs early. The symptoms go on to death, or the man recovers completely. They seldom last for more than two hours. Idiopathic Tetanus, on the other hand, is gradual, commencing with spasm of the jaw; opisthotonos comes on later; the affection may last for days, or even weeks.—(*Guy's Hospital Reports*, vol. ii. 1856.)

In treating of this subject, some confusion has arisen from the use of the word *intermission*. There is in neither case a positive intermission, or cessation of symptoms, though in both they may be paroxysmal. The apparent intermission in poisoning-cases is caused simply by the effects of one dose having gone off, and fresh symptoms being subsequently produced by another dose.

It has been supposed that the poisonous alkaloid may become destroyed while in the blood (Taylor.) I do not think we have any sufficient ground for assuming this. I think Mr. Horsley has shown that the Strychnia may sometimes escape detection in cases of poisoning by reason of its power of entering into a firm combination with Albumen, from which it cannot even be separated by an acid menstruum. Strychnia is also rapidly eliminated in the secretion of urine, and as it thus passes out of the system, its action goes off and disappears.

Strychnia causes a contraction of the muscles by stimulating the motor centres, and originating in them an impulse which is propagated along the motor nerves. So that when these centres are diseased, or the continuity of their fibres destroyed, it is unable to exert its power. It is used as a medicine in cases of Paralysis. But when the lesion of the nervous centre is of recent occurrence, or when it has been of so serious or extensive a nature as to admit of no repair in the course of time, the remedy will be ineffectual. It is only successful in cases where the injury to the nervous centre has healed up, and where the limb continues paralyzed merely because the motor nerves have lost the power to transmit the necessary impulse, from having been so long unaccustomed to the discharge of this office. It is also of use when the motor system of nerves is depressed and deranged in Hysteria or Chorea. (Trousseau.)

As it is able to act on the nerve itself, it is sometimes thought best to apply it to the affected part on a raw surface produced by a blister. The advantage of this plan is most obvious in the case of Lead-palsy, where the cause of the paralysis is local, residing in the nerve, and not in the centre. But in this case also, it is necessary that the nerve-centre be sound. Dr. Neligan recommends Strychnia in Lead-colic, in which disorder constipation and distention of the bowel are produced by a paralysis of a portion of the large intestine.

Strychnia has been used with benefit by Dr. Golding Bird in cases of Phosphaturia connected with a functional derangement of the spinal cord.

ALCOHOL.

Class II. Div. II. Ord. I. Narcotica Inebriantia.
Class IV. Ord. V. Diaphoretica.
Class IV. Ord. VI. Diuretica.

We have already considered in order the peculiarities in action that distinguish Narcotics alike from Stimulant and Sedative medicines; how they tend first to exalt the nervous forces, and then to depress them, and have further a particular action on the intellectual part of the brain. We have observed that these remedies may be divided into three minor groups, which differ considerably, if only regarded in their action on the nervous forces generally. For that Inebriants approach very nearly to Stimulants, and Deliriants to Sedatives, while Soporifics occupy an intermediate place. We have seen also that though, during the stage of stimulation, these three orders tend all more or less to excite the powers of the mind, they differ characteristically in their secondary or depressing effect upon the same. That, with respect to our present purpose, the intellectual functions may be divided into three parts: the mind itself; volition and sensation, by which it is united to the body; and the special senses, by means of which it is connected with external things. And that the secondary or depressing action of Inebriants is such as to *impair* these three in a tolerably equal degree; that of Soporifics *extinguishes* for a time sensation, volition, and the five senses, while it may leave the mind unaffected; but that of Deliriants *excites* and *deranges* all the intellectual functions.

If these things are borne in mind, the physiological action of Alcohol will be tolerably understood when it is said to be an Inebriant Narcotic. But it must be observed that when given in small quantities its stimulant effect may be the chief action manifested, its secondary sedative effect may hardly take place, and the production of Inebriation, or drunkenness, may be altogether avoided. So much is this the case that Alcohol is by some regarded as a Stimulant. But the same thing is remarked of Opium, though in a less degree. And the effects of a large dose of Alcohol are sufficiently obvious to indicate its place amongst Narcotics. For the state of Inebriation may even pass on into coma, and death.

In small quantities, for the purpose of producing exhilaration, and of overcoming various depressing causes which are of daily occurrence, alcoholic liquors of various kinds, Beer, Wine, and Spirits, are habitually employed by a large portion of mankind. On the broad and important question of their use and abuse as articles of diet this is not the opportunity to enter.

In the form of Brandy (which is more agreeable to the palate,) Alcohol is applicable as a medicine in low Fevers, in asthenic Erysipelas, in Typhoid forms of Pneumonia, and in Collapse or Syncope produced by surgical injuries or other causes. It restores the action of the heart, and enables the system to bear up against the disorder. The stimulant action may be maintained, and the secondary sedative effect prevented, by a continual repetition of the dose. Thus when once the employment of this stimulant has been determined upon, it should be steadily and unremittingly persevered in until decided symptoms of improvement have shown themselves in the patient.

The tendency of the practice of the present day is towards a freer use of stimulants, and a more sparing employment of blood-letting and antiphlogistic agents, than was some time ago prescribed. And this is probably an advance in the right direction; for in morbid actions there is altogether very little that is really sthenic; and it is, as a general rule, a wiser thing to support the system against the wearing action of a disorder, than to add to the heap of its various troubles another depressing cause.

But Alcohol is a potent agent for evil, as well as for good. When large quantities are taken continually for a considerable length of time, it is capable of producing a chronic injury of the brain and mind. By impairing the function of the former, it brings on the shaking paralysis of Delirium tremens. By an action on the mind, it causes the strange hallucinations and the habitual despondency which characterize that disorder. Habitual drinking may likewise cause a chronic inflammation of the liver, called Cirrhosis, which is succeeded by Dropsy. Alcohol is absorbed by the stomach; and, on passing through the Portal vein to the liver, may there produce this condition of the organ by the continual irritation which it excites.

Some are of opinion that the sudden denial of spirits to those habituated to their excessive use is one important cause of Delirium tremens. But this is questioned by others. From a careful observation of the inmates of prisons, who are frequently placed in this predicament, Dr. Peddie has been led to the conviction that the disorder is seldom or never caused in this way.

When taken in considerable quantity, alcohol passes out of the system by the skin and kidneys,* and thus acts as a Diaphoretic and Diuretic.

* Its excretion in the urine is denied by Mialhe. (*Chem. App.* p. 24.)

Liebig states, that when taken in small quantities it does not pass off in the secretions, but is consumed or burnt in the system into Carbonic Acid and water. He has found that persons who are accustomed to take Beer in moderation require less bread in their food. (*Animal Chemistry*, Part I. p. 96.) As it contains more Hydrogen than starchy food, and by the combustion of this Hydrogen the animal heat is partly maintained, Vierordt has shown that during the use of alcoholic liquors the amount of Carbonic Acid exhaled by the lungs is diminished. But Dr. Prout ascertained, that by the ingestion of Alcohol in considerable quantity, the amount of Carbonic Acid exhaled was first diminished, but afterwards increased. (*Edinburgh Med. and Surg. Journ.*, July, 1851.) Dr. Snow is of opinion that the spirit is entirely excreted from the system without being oxidized at all. Perhaps it is still a matter of doubt whether or not we should agree with Liebig, and believe Alcohol to be one of the calorifacient articles of food.

CHLOROFORM.

Class II. Div. II. Ord. I. Narcotica Inebriantia.
Class IV. Ord. V. Diaphoretica.
Class IV. Ord. VI. Diuretica.

Chloroform, or Terchloride of Formyle, is a volatile liquid which is analogous to Ether and Alcohol both in nature and medicinal action, but very different in chemical construction.

$$\begin{aligned} &\text{Ether} &&= C_4\,H_5,\,O. \\ &\text{Alcohol} &&= C_4\,H_5,\,O+HO. \\ &\text{Chloroform} &&= C_2\,H,\,Cl_3. \end{aligned}$$

A solution of Chloroform in spirit, sold under the names *Terchloride of Carbon* and *Chloric ether*, is in very general use, and is employed in very much the same cases as Nitric ether, being in the first place stimulant, and subsequently anodyne, soporific, and diaphoretic.*

Chloroform is physiologically an Inebriant. But it is for certain peculiar actions that are coincident with, or immediately follow, the production of inebriation, that it has been so widely and so successfully employed in medicine since its recent discovery. Its two important operations are its anæsthetic effect on sensory nerves, and its paralyzing influence on muscle.

With regard first to the general selection of anæsthetic or anodyne remedies, it is to be observed that there are four distinct kinds of Pain, which differ very much in the treatment required.

(1.) Firstly, there is *inflammatory* pain, caused by an active disease. It is aggravated by pressure; and it has a local cause. For this Opium is the best Neurotic remedy, but it should not be used without an attempt being previously or at the same time made to subdue the active inflammation.

(2.) *Irritative* pain is different. It depends merely on nervous irritation. It also has a local origin; but it is relieved, instead of being aggravated, by pressure or friction. Such is the pain produced by lead-colic, or by the passage of a gall-stone or renal calculus. The pain of Neuralgia is generally of the irritative kind. So is that of Gastrodynia. So also the pain artificially inflicted by the knife in surgical operations. For irritative pain on the surface, Aconite is most ef-

* Dr. Fleming, in an article in the 'British and Foreign Medical Review,' (July, 1853,) states his opinion that Alcohol and Nitric ether are General Stimulants, and Chloroform is a General Sedative. A more erroneous statement of the case could hardly be made, or a more uncalled-for separation of medicines obviously analogous in their therapeutic action. Any one who has given Chloric ether as a medicine must know that its action as a stimulant, soporific, and diuretic, is remarkably like that of Nitric ether.

ficacious. Belladonna comes next to it. In Gastrodynia Hydrocyanic Acid is to be preferred. But to counteract the pain of a surgical operation we require a medicine which shall be capable of producing a powerful effect on the whole system at once.* Such medicines are Ether and Chloroform. It is found most convenient to bring the patient under their influence by causing him to inhale the vapour into his lungs. Being absorbed by the pulmonary mucous surface, and passing directly into the circulation, the medicine thus takes effect rapidly. There is no time for the volatile liquid to be excreted from the blood, so that the ulterior effect of the anæsthetic cannot be escaped. Dr. Snow calculates that this effect takes place as soon as the blood has taken up $\frac{1}{36}$th part of the amount it is capable of dissolving. The third and most important advantage of this mode of administering Chloroform is that by it we are enabled to regulate with exactness the degree of its action, which is a dangerous one, and to stop it when it has gone far enough. When introduced by inhalation into the general circulation, Chloroform acts upon the brain and sensory nerves throughout the body, so as completely to extinguish their natural sensibility. It is thus an agent of immense value when we wish to save the patient from an extreme and agonizing degree of irritative pain, whether to be caused by the edge of a cutting instrument, or by the throes of parturition. But it also acts as an anæsthetic when applied locally, as to a painful ulcer, or a hollow tooth-stump, or the skin of the abdomen in Lead-colic.

(3.) The third kind of pain is *reflex* in its origin; as the pain in the knee in Hip-joint disease. We should do no good if we troubled ourselves to combat the local symptom in such a

* As early as the third century of our era, it is recorded that the Chinese made use of a preparation of Hemp to produce anæsthesia in surgical operations. This is mentioned in a Chinese book in the Library at Paris.

case; we should rather direct our attention to that condition which is the distant cause of the pain.

(4.) A fourth kind of pain may be called *centric*. Like the last, it does not originate in the painful part. It has its origin in the brain or nervous centres. Of such a kind are the various pains of Hysteria. Local anæsthetics are here worse than useless. The brain disorder must, if possible, be remedied.

Chloroform is better adapted for inhalation than Ether, because it is considerably less irritating. A mixture of Chloroform and Ether (in equal parts) has been recommended by M. Robert; and *Dutch liquid* has been tried by Dr. Snow; but the pure Chloroform is, on the whole, preferable. It is very safe when proper care is taken. We may perhaps admit that sudden deaths *have* occurred from the use of Chloroform, which could not have been avoided by any known precautions. But such an admission tells little against the remedy; for, supposing the proportion of deaths from inhalation to be about 1 in 10,000, it must be confessed that it is better that one out of that number should die of the Chloroform than that 100 should die of fright.* Out of the 9000 earliest cases of its inhalation at St. Bartholomew's Hospital, it was reported that not one died of the anæsthetic. M. Fleurens states that it was administered without one casualty to 25,000 French soldiers in the Crimea.

The stages of the action of Chloroform when inhaled may be briefly stated as follows:—1*st stage:* some alteration in the feelings of the patient; 2*nd stage:* inebriation; the mind and volition are impaired; consciousness remains; 3*rd stage:* un-

* Dr. Simpson considers that about six per cent. are saved after surgical operations by the use of Chloroform.

consciousness; anæsthesia.* The loss of sensibility may even occur in the second stage, the patient remaining conscious. The inhalation should not be prolonged beyond the occurrence of the third stage. The pulse is still full. There may be muscular movements, or even cries. In the next stage there is stertorous breathing; the eyelids no longer contract when touched with the finger; the pulse is felt to falter. This is dangerous. To this succeed stoppage of the heart and respiration;—death.

There are four rules which it is safe to follow in the administration of Chloroform; not to go on when there is stertorous breathing; not to administer it when there exists any serious disease of the heart or lungs; not to undertake under its influence an extensive operation on the mouth or jaws; and so to arrange the process as that the vapour shall be freely diluted with air. If the third rule be neglected, the blood may flow into the windpipe and cause suffocation, for the patient is deprived of the power of swallowing. The dilution with air is necessary, not only to moderate the action of the remedy, but that the necessary vital function of respiration may not be interfered with. The administration of Chloroform on a handkerchief or napkin placed close to the mouth, instead of a proper inhaler which shall provide for its dilution with air, has been the cause of most of the fatal accidents on record. This is well seen in the record of fatal cases (50 in number) in the valuable posthumous work of Dr. Snow. A larger quantity than five per cent. of the vapour in the air inspired is apt to prove suddenly fatal, by causing cardiac syncope. If in less quantity than this, the first indication of danger is observed in the breathing, which becomes slow and stertorous when the inhalation is continued too long. By

* See Pereira's 'Materia Medica,' vol. i. p. 204.

adopting a proper inhaler, and availing ourselves of this simple warning of danger, we may avoid all risk in the use of the anæsthetic. It is well known that it is convenient to administer Chloroform on an empty stomach, or it will be likely to produce vomiting.

Though Chloroform rarely fails to annihilate pain, and thus greatly to diminish the terror of the patient, it will not prevent him from sometimes dying of the shock of a serious operation. An extensive injury to the body will suffice to produce a prejudicial effect upon the heart and nervous system, which is independent of the feeling of pain, and may occur without moral suffering.

Chloroform is employed by some to relieve the pain of parturition. It is not found to interrupt the action on the uterus. (*Vide* Dr. Murphy *On Chloroform in Childbirth*, 1855, p. 37.) Although Dr. Lee has energetically discountenanced it, it seems to be more and more used among obstetric practitioners.

With the above exception, it is a general muscular relaxer and paralyzer, and may thus be inhaled before an attempt to reduce an old dislocation, or to restore a hernia of long standing. It is more efficient in such cases than either Opium or Tartar Emetic, and produces less distress than the latter. For the same operation it is sometimes employed in spasmodic disorders. It has even been known to arrest the paroxysms of that most incurable of all disorders, Tetanus. I have known it to do great service both in Epilepsy and Hysteria, when ordered to be inhaled regularly twice a day. It has been highly recommended by some who have tried it in Delirium tremens.

OPIUM.

Class II. Div. II. Ord. II. Narcotica Somnifera.
Class IV. Ord. V. Diaphoretica.

Opium is the chief member of the second division of Narcotics, which consists of medicines that, in their action on the heart are about intermediate between Stimulants and Sedatives, and whose secondary action on the intellectual functions is to produce in them the condition of sleep (p. 291.) Opium produces at first some stimulation, and exhilaration of the mind, with a full pulse, and general febrile excitement. This soon subsides, and is succeeded by drowsiness and sleep.

A considerable dose of Opium produces contraction of the pupil of the eye. A larger dose causes coma. The Deliriant Narcotics, *i. e.* Hyoscyamus, Belladonna, and Stramonium, dilate the pupil, and in large doses cause delirium. Their action is thus readily distinguished in cases of poisoning.

In defining more particularly the action of Opium, it may be stated in the first place that its active parts are absorbed, and pass into the blood. Though it is difficult to detect them chemically in that fluid itself, we may prove the point by finding them in the excretions, into which they must have passed from the blood. Meconate of Morphia has been discovered in the urine. The volatile oil of Opium has been detected in the sweat and in the breath. Infants have been narcotized by the milk of mothers who have taken Opium. Opium, if applied to a part, acts on the nerves of that part in the same way as after being taken into the stomach. On the other hand, wherever or in whatever quantity applied locally, it cannot act on the brain unless allowed to pass into the blood, so that it may reach it. In the second place, Opium acts on the nervous system. The proofs of this are simple. Applied to the nerves locally it paralyzes and deprives them of sensation.

The operations for which Opium is most famed are actions on the powers which are universally attributed to the nervous system. The effects of Opium occur immediately on absorption, a suddenness of action found in no medicine that acts on the blood. Opium produces no direct change in the blood, and has no chemical power of initiating such change. We may therefore reasonably conclude that Opium acts on the nervous system immediately and bodily, without the intervention of the fluids, otherwise than that they carry it to the part on which it tends to operate. Opium acts on the nervous system, and this is its primary and chief action. How it exerts its power over nerve, or how nerve medicines in general exert such power, I do not pretend to say. *I conceive that it is by a certain intimate or molecular relation existing between the particles of the agent and the particles of the nerve acted upon.* We have no right whatever, as far as I am aware, to call it a chemical action. The subject seems altogether beyond our ken, and in theorizing upon it we find ourselves immediately out of our depth.

I believe that all the accessory actions of Opium should be referred as corollaries to its one action on nerve, whatever that action may be.

First, let us briefly sum up in a few words the well-known operation of an ordinary dose (2–3 grains) of Opium on an ordinary adult man. The symptoms will commence, on the average, in about half an hour, the time taken depending on the contents of the stomach, and especially on whether the Opium is taken in a solid or liquid state. First comes the stage of excitement. The beats of the pulse are somewhat increased in number and fulness, the face is flushed, the mind active and crowded with ideas,—a sensation of pleasurable comfort pervades the frame. This is succeeded by drowsiness, and this commonly by sleep. The pulse and breathing are now slower than ordinary. The sleep is very sound, and attended by dreams of a pleasing or frightful nature. While asleep the patient may perspire, sometimes freely. On awaking after some hours he feels heavy and weary. There is a fulness and sense of weight in the head. There is some nausea and a furred tongue. The appetite is diminished. Constipation follows, and continues for some days.

If the dose be much larger, Opium acts as a poison. Giddiness and stupor lead quickly to a sleep of unusual soundness. The pulse and breathing are much diminished in frequency and force. The patient, if roused by shaking or loud speaking, falls asleep again immediately. He is very still—his face may be flushed, or pale—his eyes are closed. If the lids are raised, the pupils are seen contracted. The hope of safety lies in continuous forced motion, flagellation, excitement, by which the nervous system may be kept in activity till the poison has had time to be excreted from the body, which will probably happen in about twelve hours. In fatal cases the breath becomes stertorous, and fails; the pulse becomes gradually weaker, then imperceptible; all the limbs are relaxed, and the man dies in his sleep.

In all these well-known symptoms we trace as first and foremost the action on the nervous system, which I have already defined; we perceive that Opium first stimulates slightly, both the nervous system and the circulation and respiration which are under its immediate control; that it then acts as a sedative to a greater extent; that it also acts on the cerebrum, or seat of the mind, in such a manner as to cause sleep.

Annexed to this main action of Opium are other subordinate actions. 1. It causes fulness of the head, and this symptom is due to an actual congestion of the brain, a condition discovered in autopsies after poisoning. 2. It produces contraction of the pupil of the eye. 3. It causes constipation, and diminishes the secretion of the intestinal glands, as well as the bile, urine, and most secretions. 4. It causes sweating, and increases the secretions of the skin. (It also relaxes the muscular system, an operation which is probably not direct, but due to its action on the motor nerves.)

In attempting to give any regular order or sequence to these symptoms, or to explain them on the principle of mutual dependence, we are liable to become involved in a maze of contradictions, doubts, and difficulties.

I may show this by adducing a variety of explanations which might be offered, or actually have been offered, of some of these symptoms. How does Opium cause congestion of the brain? Some answer, by hindering the circulation; this is the action of a sedative. Certainly not. Belladonna is a sedative, and produces anæmia of the brain, resulting in delirium. It is the stimulant action of Opium, say others; this causes an afflux of blood. But it occurs just in those extreme cases where the stimulant action of Opium is almost imperceptible, and is synchronous with its secondary or sedative action. Again, is the congestion the result of the action of excretory matters? Retention of urine, or of the fæcal secretion, might cause congestion of the brain. Experience and observation go to prove that Opium scarcely, if at all, diminishes the secretion of urine. As to the secretion of the bowels, constipation may continue when the cerebral symptoms have disappeared.

How does Opium cause constipation? It is not an astringent in any true sense. Yet there is no astringent like it in its action on the bowels. Does it hinder excretion by paralyzing the intestinal muscle? Or by diminishing the production of bile, the natural purgative, as some say? Or does it control the metamorphic processes in the system, and so actually diminish secretion? If so, why is its action so confined to the bowels? Some urge (Matteucci) that Morphia has an influence in suspending the process of endosmosis, and that thus it diminishes secretion and impairs digestion. This physical property has been shown to have no real existence. Did it exist, it would be difficult to see how Morphia itself could be absorbed.

How does Opium cause sweating? Is it as a sedative that it relaxes the skin and muscular fibres of the ducts of the glands? Is it by elimination? The volatile oil of Opium has been smelt in the perspiration, but Morphia alone causes sweat, and it is not so certain that it passes thus.

How does Opium cause contraction of the pupil? Some say it is as a stimulant; others, as a sedative. But neither other stimulants nor other sedatives manifest this phenomenon. Some attribute it to congestion of the brain, but this, I should conceive, would be more likely to dilate the pupil. I believe the contraction of the pupil to be an action altogether peculiar to Opium, and one exerted by no other medicine whatever. It is probably an action of special irritation, either of the optic centres, or of the ciliary nerves directly. The irritation of light, or mechanical irritation, contracts the pupil. Belladonna, and other medicines, which are more distinctly sedative than Opium, dilate it.* (See p. 294.)

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* It is supposed, by Dr. R. Hamilton and Mr. B. Bell, that contraction and dilatation of the pupil depend on the stimulation of one or other of the sets of nerves that supply the iris: it being assumed that the third nerve supplies the circular fibres; and a branch of the sympathetic, the radiating fibres. Thus stimulation of the third, it is thought, would cause contraction; stimulation of the sympathetic (or of the anterior roots of the spinal nerves which communi-

Many explanations applied to the general action of Opium, considered as a whole, are every whit as unsatisfactory as those which I have condemned as insufficient to account for the several parts of that action.

There is, first, a chemical theory, to account for the production of Narcotism by medicines absorbed into the blood. It is advocated by Mialhe and Robert in France, and by Drs. Snow and Richardson, and others in England, and seems to be founded upon an idea similar in nature which first occurred to Liebig. It is supposed that all Narcotics act by retarding the combination of Oxygen with the tissues. That they thus check the vitality and control the functions of the latter, and of the nervous tissues more particularly. As I have argued at some length against this in the Section on Narcotics, I shall content myself with a simple allusion to the objections there made to it. Chemical arguments derived from reflections on bodies of the Alcohol series, cannot well be applied to Morphia, as this differs from them so much in its chemical properties. Such alkaloids as this exert no influence that can be discovered over the process of oxidation. A diminution in the amount of carbonic acid exhaled is no proof of chemical action, but simply a result of the diminished number of respiratory acts. Morphia acts directly on the nerves when applied locally, without any opportunity of interfering with the blood processes. Again, if Narcotics act by disoxygenation, how do stimulants act? Do they promote oxidation? They produce a contrary effect to sedatives. Most difficult of all is it to explain how the same medicine, as Alcohol or Opium, should first stimulate, and then do the contrary. They cannot both promote oxidation, and retard it. The immense varieties of action amongst different Narcotics and Sedatives, the peculiarities of different systems, different animals, different races of men, are things which it is quite impossible to explain by any such theory as this.

At one time, I myself thought it possible that some of the secondary actions of Opium might be referrible to the retention of Carbonic Acid gas in the blood. But reflection convinced me that this could not, at all events, be the sole cause of the sedative effects of the drug. I could see no reason why CO_2 should be retained, except the action of Opium in diminishing the number of the respirations, as with this diminution the diminishing of CO_2 excreted keeps pace. Now, as this action on the respiratory function is obviously on account of the sedative influence of the

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cate with it) produce dilatation of the pupil. (*Edin. Med. Journal, July*, 1856.) Or, on the other hand, paralysis of the third might cause dilatation, by allowing the influence of the other nerves to preponderate; and paralysis of the sympathetic, in the same manner, induce contraction. And this theory, the antipodes of the other, though founded on the same *data*, has been defended by Dr. Harley. I have already adverted to this interesting question, when speaking of the action of Belladonna.

Opium, how can we, admitting this, reasonably deny the exertion of other sedative actions by the same drug. To admit them seems better than to attribute them to the retention of a gas, whose existence in the blood in all cases of the action of Opium is rather presumed than proved.

Some ascribe the secondary or sedative actions of Opium to the re-action of the system from its primary stimulant action. But the two are so entirely disproportionate that this cannot in any reason be admitted.

That one and the same substances should first stimulate and then depress the functions of the nerves and of mind, is a difficult thing to explain in any way,—but no more difficult in the case of Opium than in that of Alcohol. Oil that is poured on a fire, first causes it to burn more freely, and then extinguishes it. Some local applications to the body cause smarting at the first but a sense of comfort afterwards. So it may be that the particles of Opium, when they first come in contact with the nervous substance, may offend it, and cause some irritation on account of their foreign nature, but after the two reagents have had time to become more adapted the one to the other, the particles of the Opium may so fit amongst and cloak the ultimate particles of the nerves, that they more or less extinguish or suspend their natural vital sensibility.

Considering the drug only in its secondary or more important actions, it may be said that Opium is the most perfect nervous sedative that we possess. It controls the action of the heart, and diminishes the frequency of the respirations; it benumbs the sensitive nerve, and paralyzes the muscular tissue. But these are common sedative actions, exerted still more rapidly and completely by such substances as Aconite and Prussic acid. Opium further paralyzes the organic nerves, putting an end more or less to the vital contractility of the intestinal walls, which depends on the sympathetic system. What is far more important, it has an action on the brain, of which the others are destitute. It destroys for a time its influence over the body, its power of co-ordinating emotions or receiving impressions. It suspends the action of the special senses. In a word, it causes sleep. Under the action of Opium the whole material nervous system without exception is quieted and controlled. The immaterial part, the thinking mind itself, is the part that is the least interfered with. It may wander far in dreams, cut off from all knowledge of the external world, and debarred from all intercourse with it—a disembodied spirit, that for a time has lost its hold of matter.

The fact that the actions of Opium centre in the brain,—that, as far as regards the mind itself, they partake somewhat of a stimulating character,—and the fact of the invariable connexion of sleep with fulness about the head,—may, together or singly, be considered to account for the cerebral congestion which accompanies the action of Opium.

The increase in the perspiration may perhaps be explained best on the supposition that the principles of Opium tend usually to quit the body by means of the sudorific glands. The constipation is probably dependent on a number of concurrent causes,—partly, it may be, on a kind of palsy of the peristaltic motions of the intestines; partly on a diminished amount of material to be excreted, depending on the torpid condition of the whole system.

Some specific peculiarities in the operation of Opium may seem to require notice. On many of the lower animals it produces much less action than on man. To rabbits and other rodents a large quantity must be given to prove poisonous. To apes it is scarcely deleterious. Flandin administered to one 500 grains of Opium without effect. This seems to be on account of its rapid elimination in the urine.

On human systems its action varies. To some it is chiefly excitant, except when in large doses. To others it is dangerous in a small dose. Some are easily brought under its influence, and sent to sleep; with others, on account of a peculiarity sometimes hereditary, it is difficult to do this. To children, and especially infants, Opium is dangerous, and should seldom be given, or even then in very small doses, as they are especially susceptible of its action. To persons habituated to its action, larger and larger doses must be given to produce any marked effect, as a rapidly increased toleration of the drug is exhibited in such cases. A quantity that ordinarily would destroy a whole family, would be nothing to an opium-eater. A woman with cancer of the uterus has been known to take laudanum by pints!

The existence of a morbid condition which is contrary to the known action of Opium, causes great tolerance of the remedy. In acute pain or delirium, large doses may fail to take effect. In Asiatic cholera or colliquative diarrhœa, laudanum may be poured into the stomach with little more effect than water.

It has been remarked that Opium takes most effect in warm, moist weather. This retards excretion of the Morphia by the urine, and throws it chiefly on the skin, by which avenue its elimination probably occupies a considerable space of time. Thus the patient to be brought under the influence of Opium should be kept sufficiently warm, and in a recumbent position. He should not drink too much fluid, as this would help to carry off the narcotic sooner than is desired.

Having spoken of the mode of operation at some length, I have next to speak of the medicinal uses of Opium.

Opium, as a Sedative, depressing the nerves of sensation, removes the feeling of *pain*. Also, by producing sleep, it suspends feeling for a time. As a soporific, it counteracts morbid *wakefulness*. In inflammations and many diseases it does good, not so much as a Sedative, lowering the heart's action, but rather from its power of allaying the increased *susceptibility* of the nervous system to morbid impressions. When the brain is continually worked upon by such agencies, delirium or aberration of mind results. Opium, as a soporific and soother, is a direct antidote to delirium. By its influence over the motor system of nerves, Opium relaxes the muscular system universally. It thus controls *spasm*, a tendency to morbid contraction of the muscles, or an actual existence of such contraction.

These are the great medicinal actions of Opium. The others are but subsidiary, and of small importance. Opium produces sweating, and, by its constipating action, counteracts a flux from the bowels. Thus the four great indications for Opium are—

Pain,
Wakefulness,
Nervous excitability,
Muscular spasms.

In the terrible varieties of pain that from various causes may rack the feeble body of man, the very worst tortures of disease consist. In the loss of sleep we recognise a continual symptom of many disorders, acute and chronic, and a symptom that more than any other, perhaps, exhausts the strength of the sufferer, and hastens him to his end. In nervous excitability we discover the cause of the delirium of fevers, of all the forms of madness, of the tremors, fears, and startings of Hysteria and Anæmia, of a general susceptibility to disease in weak constitutions, and of aggravation of all their symptoms in those who already suffer. In spasm we perceive a prominent symptom of Epilepsy, Tetanus, and other terrible disorders, and an occurrence that mechanically retards the cure of some local diseases.

In fact, in these four morbid symptoms we have those very symptoms of disease by means or in consequence of which disease is so often fatal. In Opium we have a medicine which exerts a direct control over all of them. Opium therefore, without exaggeration, may be called our very sheet-anchor in the counteraction of the symptoms of disease. But can we always make use of it? It would be very fortunate if we could do so. Unhappily there are certain counterindications, the existence of which is to warn us against the administration of Opium. Opium at first irritates the stomach, somewhat increases the pulse, causes an increased heat of the body, and produces congestion of the brain. Thence the counterindications,—when the pulse is quick, full, and hard, the tongue coated, the stomach irritable, the skin hot and dry, or there is any determination to the head, or congestion or inflammation of the brain, we are not to give Opium.

The administration of Opium to children, except in very small doses, is well known to be perilous. Putting this aside, and speaking only of grown persons, it is to be observed that the head symptoms form the only contraindications which cannot occasionally be disregarded by the wise, or counteracted by the skilful practitioner. A state of brain which produces contraction of the pupil, as occurring in some fevers, is a strong sign of the danger of administering the drug.

But, with these exceptions, it may be said that if there is any general practical fact which may be derived from an examination of the therapeutic history of Opium—it is this, that the indications which call for its use should be more regarded than the countersigns which oppose themselves to it. When the patient is tortured by pain, tosses about on a sleepless bed, or raves in a senseless delirium, the one remedy for his case is Opium, and to administer this one fitting remedy in some manner, but if possible without risk, must be our great object. We have at our command various means and modes of combination, by which we may defeat, more or less, the several counter-symptoms. Does a hot skin make us pause? We can give the Opium with Ipecacuanha in the form of Dover's Powder, or in solution with Acetate of Ammonia. Are we prevented from using it by the loss of appetite and general feebleness of the patient? We may combine it with Quinine. Is there constipation? We may give it with Calomel, or a saline purge, though both tend to diminish its activity. We may do the same in tendency to fulness of the head. Does fever dissuade us from hazarding Opium? We may combine it with Tartar Emetic, which tends to subdue that fever.

Among other therapeutic combinations, we are accustomed to give Opium with Chalk in Diarrhœa, and with Camphor (an expectorant) in Bronchitis.

In fevers and inflammations generally, whenever the pain, excitement, or delirium, are out of proportion to the quickening of the pulse, we may give Opium, or we shall expose the patient to a greater risk than any which results from its action. The only decided contraindications here are, a tendency to coma from cerebral congestion, or a tendency to apnœa, —embarrassed respiration. Thus in inflammations about the head, and in lung diseases, especially where the respiratory channels are choked with mucus, Opium should generally be avoided.

In all painful diseases of the stomach and intestines it may be prescribed with benefit. In Diarrhœa and other fluxes; though in Cholera it does no good. In the painful inflammations of the serous membranes, especially peritonitis of all kinds. In acute inflammation of the joints, as Gout and Rheumatism, it often does great good, both externally and internally. In spasms or convulsions it is a direct antidote; but the causes of Tetanus, Epilepsy, and Hydrophobia are too firmly seated to be warded off by a temporary remedy.

In Delirium tremens, and in all cases of delirium unattended with high fever, it may be said to be our sole reliance. In the irritability of system which often keeps up local inflammation, as Ophthalmia, Orchitis, sores, and ulcerations, Opium is of great use. It was used with success in Syphilis by Sir Alexander Grant. As a promoter of sleep in long and lingering diseases, and as a reliever of pain, from whatever cause produced, it is invaluable.

Paracelsus said well of Opium, "Tam homini, quam morbo, somnum conciliat." It may send the disease to sleep, as well as the patient.

As a Diaphoretic in fevers and inflammations, Opium is to be preferred in cases where the skin is already moist and cool, where the pulse is soft, and the tongue not coated. But where there is febrile excitement, Antimony, or Ipecacuanha, is rather indicated. Opium may act on the glands of the skin as a true Eliminative; or it may possibly operate in the same indirect way as a nauseant dose of Tartar Emetic, relaxing the ducts of the sudorific glands by its paralyzing influence on their muscular fibre.

The chemical construction of Opium is a matter of considerable interest. Morphia, the chief active principle, is an alkaloid which is almost identical with Opium in its narcotic action, but slightly more sedative. Unencumbered by inert matters, it presents us with an anodyne in a more concentrated form. But the combination of the Morphia with other principles in the crude Opium is worthy of remark.

Codeia, another alkaloid, has been found by Trousseau and Pidoux to have the same action as Morphia, but to be ten times weaker. Narcotine is a crystalline neutral principle, which was affirmed by Derosne and Magendie to act as a powerful Narcotic. Others, as Dr. O'Shaughnessy, have found it simply a tonic, like Quina. This discrepancy has been in great part accounted for by a late discovery by Winterberger, *i. e.* that Narcotine, as frequently prepared from Opium, contains about half its weight of a new alkaloid, Opiana, which acts upon the system in the same manner as Morphia. The volatile oil of Opium can with difficulty be isolated: it appears to be narcotic. Four other neutral principles, Narceine, Meconine, Papaverine, and Thebaine, are contained in Opium. Porphyroxine and Pseudomorphine are occasionally present. All these, except Narceine, are present in very small quantities, and the only one that has any marked action on the system is Thebaine, which is said to have an operation like that of Strychnia.

Morphia is doubtless the chief active principle of Opium; but it can hardly be the only one. Opium of Smyrna, according to the analysis of Mulder, contains about 11 of Morphia in 100 parts, 7 of Narcotine, 1 of Codeia, 6 of Narceine, 4 of Resin. In some manner he disposed of the volatile oil, which others set down at two to three per cent. Now Morphia may be fairly concluded to be about four times as strong as Opium, and yet does not form one-eighth part, even of the best specimens. We must look somewhere for active elements equal at least in weight to the amount of Morphia, before we can satisfactorily account for the effect of the drug. If about one-half of the Narcotine and part of the Narceine consist of Opiana, we may have perhaps four per cent. of this; but as this is based on the incomplete researches of Winterberger, it is a surmise that needs confirmation. There may be two per cent. of narcotic oil. I do not know whether we should add the *resin*, a name to which every analyzer of Opium seems to attach a different, and generally an indefinite idea. But as Dr. Garrod has found that giddiness and contraction of the pupils are produced by the resin of Opium, perhaps we may reckon, provisionally, four per cent. of this. So that in our present imperfect state of knowledge as to the active ingredients of Opium, they may be enumerated somewhat as follows:—

Morphia.	12 per cent. (some lost.)
Opiana	4 "
Narcotic volatile oil	2 "
Narcotic resin	4 "

making a total of 22 per cent., which perhaps expresses with some approach to correctness the narcotic element of the drug.

Narcotine, the bitter element of Opium, may fit it for administration in some cases where Morphia is comparatively inappropriate. Thus, in delirium tremens, where it is by all means advisable to promote the appetite and preserve the activity of the digestive powers, Opium is frequently more useful than Morphia. The one, and perhaps only advantage which Morphia and its salts have over crude Opium, is their purity, and the constancy of their action resulting from this. If we could obtain Opium which always contained the same amount of Morphia, it would perhaps be better to use the alkaloid as naturally combined, in all cases.

The consumption of Opium annually is no doubt on the increase with us. Some exaggeration has been caused by reckoning up the whole amount that passes through our ports. Taking only the quantity that is returned for home consumption, we find that from 1831–41, the average was about 35,000 lbs., but in 1853 it reached the sum of 62,500 lbs. If various sources of information, comprising the testimony of medical men and dealers in drugs, can be at all depended on in this matter, I fear there is no escape from the melancholy conclusion that this increased consumption is in large part owing to the growth of the pernicious practice of Opium eating, among the lower classes especially. Driven to it in time of want, to allay the cravings of hunger, or drown the gnawing sensation produced by enforced abstinence from spirituous liquors, or impelled thereto by the belief that it tends to strengthen the frame against the influence of a damp and unwholesome climate, the operative in the manufacturing districts, or the field-labourer in Lincolnshire, resorts once to Opium, and is thenceforth riveted for life to the fascinating but baleful drug. Moreover, every year a larger proportion of Opium is abstracted from its legitimate uses, in order to enter into the composition of those various detestable compounds, with which, under the names of Godfrey's Cordial, Dalby's Carminative, Soothing Syrup, etc., mothers, whose pitiable ignorance must serve for their plea, are suffered to stupefy and poison their helpless babes. And the Government has not interfered, and will not interfere to stop this. Most wisely has the sale of Arsenic been restricted by law. But any one may buy Opium. The recorded deaths from suicide and murder, which result from its unrestricted sale, are increasing in a frightful ratio.

Opium-eating, to an enormous extent, has been long practised in the East. The drug is resorted to on account of the pleasurable sensations which result from it. The mental faculties are said to be enlarged; a state of mind is felt which is described as perfect happiness; the ordinary capacities of enjoyment are refined and amplified. Dreams and hallucinations of a wondrous but agreeable kind present themselves to the thinker—but there is no intoxication like that produced by alcohol. To his friends, the Opium-eater may seem a grave, silent, and abstracted person, or his flow of conversation and expression of his ideas to others may be more remarkable and more vivid than theirs. At length he sleeps, still dreaming; sleeps long, and when awoke, still feels drowsy. Now his head aches, his frame is unusually weary, his tongue is coated, his appetite gone, his eyes dull and listless; he longs to sleep again. Soon there comes a depression and misery of mind which is described as intense. To cure this the wretched man knows but one way. Death would be better than its continuance. He takes Opium again. And so he goes on, till the daily stimulant must be added to, to produce its usual effects. From one grain of Opium, or twenty drops of laudanum, to one drachm of Opium, or ounces of laudanum, he goes on—along a terrible and slippery incline which in this world has no end. It produces, it is said, a disinclination to all business, and yet, while its influence lasts, a singular ability and aptitude for employment, mental or physical. Two of our greatest writers, it is rumoured of more, but two at least,—Coleridge and De Quincy,—were Opium-eaters. And here I tread upon ground from which I would fain keep aloof. Humiliating and painful it is to be obliged to confess that, after all, "The Ancient Mariner" and "Christabel" may have been but Opium dreams,—that the "Suspira de Profundis" are the fumes of a drug, sad ravings Opium-inspired.

Opium-eating once contracted as a habit, is far more difficult to shake off than the practice of alcoholic intoxication. The torments of a drunkard deprived of his accustomed stimulus, described so graphically by Charles Lamb, are as nothing to the sufferings of the devotee to Opium when striving to release himself. "His sufferings," says Oppenheim, "when deprived of the stimulant, are as dreadful as his bliss is complete when he has taken it. Night brings the torments of hell; day the bliss of Paradise." "Effects," says Coleridge, "were produced, which acted on me as if by terror and cowardice of pain and sudden death." And the English Opium-eater compares his sufferings, when attempting to break off the vice, an attempt in which at last he succeeded, to the torture of the rack.

By long indulgence in the drug, the frame is weakened and emaciated, the powers of digestion and assimilation are impaired, and the life is shortened. However, some have pronounced the habit to be less dangerous than an indulgence in intoxicating drinks.

The amount of Opium used in China has gone on annually increasing since the failure of the Chinese government to prohibit the importation cf Opium from India, an attempt which is well known to have led to the first Chinese war. Opium in China is seldom eaten,—it is smoked, *i. e.* it is burnt in a pipe of peculiar construction, and the fumes are inhaled. Morphia, the active principle of Opium, is not volatile, so the smoke of burning Opium cannot contain it, but it contains a volatile oil which is natural to the drug, and an empyreumatic oil resulting from the combustion of the Morphia, Narcotine, etc. Thus its action is in nowise to be compared with that of opium taken into the stomach in its original form. The question of Opium-smoking is beyond my present province. I shall therefore not enter upon it—further than to remark that it seems to me that its results may be compared to those of smoking tobacco to excess; that it is not so deleterious as some have affirmed, relying on exaggerated statements made by men who are not personally cognizant of the facts; that it is not so prejudicial to health as the practice of spirit-drinking; and that it seems that it seldom or never causes premature death. To these opinions I have been led by a process of balancing between many conflicting statements that have from time to time been made on the subject. See "Papers relating to the Opium Trade in China," presented to the House of Commons in the year 1857.)

HYDROCYANIC ACID.

Class II. Div. III. Ord. I. SEDANTIA GENERALIA.

Hydrocyanic or Prussic acid (C_2 N, H,) a very volatile liquid, soluble in water, is one of those mysterious vegetable compounds which, containing no chemical element that is not also contained in animal structure, are yet gifted with a wonderful power over the vital forces. One drop of the pure acid is sufficient to cause death. But the officinal acid is an aqueous solution, containing only two per cent. of the other.

It is a powerful Sedative to the nerves generally. Its action is direct, and is not preceded by any primary stimulation. Diminishing sensibility, it is therefore used as an anodyne. Controlling muscular action, it is employed as an anti-spasmodic. But it appears especially to influence the reflex nervous actions. It is therefore of especial use in the paroxysmal coughs of Hooping-cough and of Phthisis, which have a reflex origin in the irritation of the mucous membrane. It acts on nerves as well as on nerve-centres. Thus it is particularly useful in neuralgic forms of Gastrodynia; and it seems to allay the pain in the stomach by diffusing itself directly it reaches it, so passing through the mucous membrane at all points, and coming in contact everywhere with the irritated sensory nerves. It is sometimes useful in cases of vomiting, or pyrosis.

If applied to the surface of the skin, it numbs the superficial nerves; but on account of its rapid volatility, and the dangerous results that would follow the inhalation of its vapour, it is not appropriate as an external anæsthetic.

A poisonous dose produces first convulsions* of the whole frame, then syncope, and death. It paralyzes the action of the brain before it affects the heart; for, some minutes after apparent death, the heart may be found beating. (p. 296.) Strychnia produces convulsions, but they are not caused in the same way as those of Hydrocyanic acid. For the two medicines are obviously opposed in their action, Strychnia being an exalter of sensation and of reflex action, and Hydrocyanic acid a depresser of the same. The convulsion caused by Strychnia is tonic; that by Hydrocyanic acid, asthenic. The one, being

* Dr. Paris has hazarded the conjecture that the convulsions of Pythonesses such as those of the Cumæan Sibyl mentioned in Virgil, were produced by chewing the leaves of the cherry-laurel. (*Pharmacologia*, 9th edit. p. 11.)

a special Stimulant, causes convulsions by an excitement of the spinal cord; the other, being a Sedative, does it by deranging the function of that centre.

ACONITE.

Class II. Div. III. Ord. I. Sedantia Generalia.

This medicine, like the last, is a powerful General Sedative and a dangerous poison. It depresses the influence of the brain, and paralyzes all the nervous functions. It tends at length to kill by producing syncope.

It acts especially on the superficial sensory nerves, and tends to extinguish feeling and pain. It is the best external anæsthetic with which we are acquainted. It is thus eminently useful in the treatment of that most painful of all disorders, Tic douloureux, or irritative Neuralgia of the face. When Quinine and all internal remedies have failed, the tincture of Aconite, or an ointment containing the alkaloid, will in most cases, if applied to the part, effectually relieve the pain. It is applicable in local irritative pain at any part of the surface, as in Sciatica, Lumbago, or a Scirrhus of the breast that has not opened. But, like the other local anæsthetics, it is of little service in cases of inflammatory pain; for this, when local, depends upon an active cause, and would be liable to be increased by the rubbing required in the application of the Aconite. When the remedy takes effect, some heat is first experienced at the part; there is then tingling; and lastly, complete numbness, and a sensation of cold, which endure for some time. No visible change is effected.

Aconite subdues the action of the heart. Dr. Fleming has therefore recommended small doses internally in cases of acute rheumatism. But considerable care is required in the internal employment of the drug, on account not only of its dangerous properties, but of the great variety in strength which exists among the preparations that are usually employed. The difficulty experienced in the preparation of the alkaloid Aconitina, which is the active principle of the plant, and the very high price at which that substance is usually sold, have prevented it from being so extensively employed in practice as its medicinal properties would appear to deserve for it. On account of its cleanliness as an outward application, and the certainty and uniformity of its sedative and anæsthetic actions, the pure alkaloid is far preferable as a medicine to Aconite itself, and is adapted for all the cases in which the latter has been employed.

Having some time ago been successful in an attempt to discover a mode of preparing Aconitina,* I have made some experiments with it on various small animals, for the purpose of ascertaining its power, and the symptoms of its action. It is a very active poison. Proceeding upwards in the animal scale, I find that $\frac{1}{300}$th of a grain, in solution in water, suffices to kill a mouse. $\frac{1}{100}$th kills a small bird after a few minutes; $\frac{1}{30}$th almost instantaneously. $\frac{1}{20}$th of a grain has killed a cat. $\frac{1}{10}$th invariably proves fatal to the unfortunate feline in the course of twenty minutes or half an hour.

Calculating as well as I can from these data, I consider that $\frac{1}{10}$th of a grain of this alkaloid would be sufficient to cause the death of an adult man. During the action of the poison on cats the following succession of symptoms is generally observed. They will illustrate in most of its phases the action of a Sedative medicine.

1. An increased flow of the salivary secretion. (*Vide* p. 339.)
2. Vomiting.
3. Delirium, with hallucinations. Impairment of volition; apparent loss of sensation.
4. Convulsions; paralysis.

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* See account of the mode of preparation, by the Author, in the second and third editions of Dr. Royle's Manual of Materia Medica.

5. Breathing difficult and gasping,—gradually ceasing.
6. Death; pupils of the eye are seen to be dilated.*

Aconitina has thus a powerful action on the brain, and on the nerves generally. The flow of saliva seems partly to arise from a paralysis of the fauces. The animal makes ineffectual attempts to swallow, and breathes spasmodically. By a small dose the anæsthesia would probably be produced without the other effects. On examination of the body after death the lungs are found to be healthy, but shrunken and bloodless; the trachea contains much frothy mucus, which may possibly have flowed into it on account of a palsy of the glottis; the cavities of the heart are full; the mucous membrane of the stomach pale. It seems then that the actual cause of death is paralytic syncope,—a loss of power in the heart. But preceding this, as with most other Sedatives, is a complete arrest of the vital functions of the brain. As the mucous coat of the stomach evinces no trace of congestion, it is probable that the vomiting is not caused by irritation, but by a sedative or deranging action on the function of the Vagus nerve.

During the last few years so many cases of poisoning by Aconite have occurred, that they have done much to bring this valuable medicine into unmerited disrepute. As one safeguard against such occurrences, I would recommend that all the preparations of the root and leaves in common use should be eschewed. For the plant contains a very variable proportion of its active principles, and the dose which may be given with impunity of one preparation, may prove fatal as soon as the stock of the medicine is changed by the druggist. It would be better to sub stitute for all such preparations a dilute solution of the alkaloid, of uniform strength and known power (such as the *Liquor Aconitinæ* recommended by me.) This will be the best safeguard against accidents from the cause just mentioned.

* Some say, contracted. In the records of poisoning the statements as to this point vary. I am informed by Dr. Maclagan that in the lamentable cases at Dingwall, in 1857, the pupils were not observed until after death, and were then nearly natural in size. Schroff and Von Praag give dilatation of the pupil as one symptom of the action of Aconite.

I may here give a warning against the enormous doses of Aconitine said to have been given by Schroff and Von Praag in Germany—(·02–·05 *gramme*, or $\frac{1}{3}$–$\frac{3}{4}$ of an English grain.) If the alkaloid were pure, such a dose would certainly cause death. (*Brit. For. Rev.* 1856, p. 244.)

In cases of poisoning, when early discovered, the best, and indeed the only antidote, consists in the copious administration of finely-powdered animal charcoal mixed with water. This will absorb the alkaloid, and so firmly unite with it as to prevent it from entering the system. After a short time the whole may be cleared out by a zinc emetic. But vomiting should by no means be encouraged before the administration of the Charcoal, as this would favour the absorption of the Aconite by producing nausea, and so hurry on the fatal issue. The emetic should certainly be postponed until means have been adopted to fix and render innocuous the active principle of the poison. (*Royle's Materia Medica*, 3rd edition, p. 272.)

DIGITALIS.

Class II. Div. III. Ord. II. Sedantia Specifica.
Class IV. Ord. VI. Diuretica.

This important medicine has already been prominently noticed as one of the agents that exert a special sedative and deranging power over the functions of the Vagus nerve. It will only be necessary now to sum up shortly the details of its action.

Digitalis does not depress nervous force generally. It has no action on the brain, except as connected with the Vagus nerve. Neither does it affect the spinal cord, or the nerves of sensation or motion. Its most obvious action in small doses is to depress the force of the heart. It sometimes quickens the pulse, but always weakens it, and reduces its rate in the end. It therefore supplies us with a ready means of weakening the heart, whenever we desire to do this. In cases of hypertrophy, where the heart is too strong,—or in aortic aneurism, or active hemorrhage, where a forcible beat would be dangerous,—Digitalis may be used for this purpose. But it is especially useful in dropsies; for, by its action on the heart, it diminishes congestion of the venous system, and by thus removing the pressure from the veins, it favours the absorption of the fluids effused. It should however be avoided in cases where there is a very serious cardiac obstruction, or where the heart is habitually weak, and there is a natural liability to syncope. For the tendency of the medicine is to cause death by producing syncope.

Certain precautions are necessary in its administration. The patient should be generally confined to the recumbent posture; for if, while under the influence of Digitalis, he should suddenly rise, and the heart, already weakened, have further to contend with the force of gravity in the propulsion of the blood upwards, it may actually stop. The dose also should be cautiously regulated, and if it do not operate at once, it must not be increased, or too soon repeated; for this medicine is apt sometimes to accumulate in the blood, and though several doses may perhaps be given without effect, they are afterwards liable at any time to be suddenly discharged upon the nervous system, and may then produce by their united action a dangerous result.

A considerable dose of Digitalis, as of Tartar Emetic, deranges the control of the Vagus nerve over the function of the stomach, and may in this way produce nausea and vomiting. There is no reason for supposing that it irritates the coat of the stomach. (*Vide* p. 107.)

The active principle of Digitalis is secreted from the system in the urine, and probably acts as a true Eliminative Diuretic. But it tends more powerfully to promote diuresis in another indirect way. Anything which diminishes the pressure on the vascular system, as Digitalis by weakening the force of the heart, tends thereby to promote absorption, and to increase the secretion of urine.

So that the employment of Digitalis in dropsy is attended with a twofold advantage: by its cardiac action, it prevents a renewal of the dropsical effusion; by its diuretic power, it causes a quantity of fluid to be drained out of the system through the kidneys. That it may do this the more effectually, it is generally considered advisable to combine it with other diuretics. It has sometimes been found convenient to administer Digitalis externally; cloths being dipped in its infusion, and applied to the surface of the abdomen, the remedy may thus become absorbed, and evince its action on the system. Digitalis owes its power to an active alkaloid, Digitalia, which has been found by Leroyer to act in small doses as a poison on animals, which it kills by gradually stopping the pulse and the respiration.

TANNIC ACID.

Class III. Ord. II. Astringentia Vegetabilia.

This is the chief astringent principle of vegetables. It is very soluble in water, crystallizable, and has a strong astringent taste. It is not possessed of those marked properties that are vulgarly attributed to acids; but its solution reddens litmus-paper, and it combines with bases to form salts.

When received into the stomach it is absorbed, and passes in the circulation to distant parts. Its action consists in a power of causing the contraction of muscular fibre when in contact with it; and this power appears to depend mainly upon a chemical property that it possesses of coagulating albumen and analogous compounds. Capillary vessels, and the small ducts of glands, contain in their walls certain fibres of unstriped muscle; and Tannic acid, by causing this muscle to contract, is able to diminish the calibre of these tubes, and thus to moderate or arrest the flow of blood in the vessel, or to lessen the amount of the excretion of the gland. Thus, in all cases of hemorrhage from the small vessels, or of inordinate secretion from any glandular organ, Tannic acid is appropriate. It is the best and safest of all astringents for internal use, excepting only Gallic acid.

I have already stated, as worthy of remark, the fact that Gallic acid is of little or no use as an Astringent when applied to external parts. Given internally, it is very efficacious. From this alone it would seem that there must be something in the blood which enables it to take effect. Reasons have also been alleged for supposing that Tannic acid is not a simple substance. When it is taken into the system, Gallic acid is secreted in the urine; and it appears that Tannic acid must actually consist of Gallic acid combined with certain other elements, or with some other definite substance; and that the astringent property which is so valuable is confined to the compound body thus produced.

What then is this other substance? It must be something which is contained in or formed in the blood; which, added to Gallic, will be capable of forming Tannic acid; and which, when united to it, will enable Gallic acid to precipitate Albumen. These various requirements are fulfilled by the group of elements that constitutes grape-sugar ($C_{12}H_{12}O_{12}$.) This compound is continually forming in the blood during the blood-processes that are connected with respiration. It has been observed that a solution of gum ($C_{12}H_{11}O_{11}$,) added to one of Gallic acid, will enable the latter to coagulate Albumen. And the elements of Tannic acid may be constructed out of those of Gallic acid and grape-sugar.

$$\text{Tannic acid} = C_{18}\,H_6\,O_{10} + 2\text{ aq.}$$
$$\text{Gallic acid} = C_7\,H\,O_3 + 2\text{ aq.}$$

Three equivalents of anhydrous Tannic acid amount to six of Gallic acid and one of grape-sugar.

$$3\,(C_{18}\,H_6\,O_{10}) = 6\,(C_7\,H\,O_3) + C_{12}\,H_{12}\,O_{12}.$$

So that it is very probable that when Gallic acid is taken into the blood, it acts as an Astringent by co-operating or uniting with the elements of grape-sugar in that fluid. But when Tannic acid is received into the organism, and has done its work there, it is finally decomposed, Gallic acid passing out into the secretions, and the sugar being retained in the body for combustion into carbonic acid and water. (P. 322.)

Dr. Strecker has lately established the correctness of the above surmise, by showing that Tannic acid may be resolved by the action of mineral acids into Gallic acid and Grape-sugar. (*Trans. of Chem. Society*, March 15, 1852.) But about the exact formulæ of Tannic and Gallic acids there is still much doubt. (See *Fowne's Chemistry*, 4th ed. p. 501.)

The principal vegetable substances that are employed as Astringents are said to contain Tannic acid in about the following proportions:—

Kino	70 per cent.
Oak-galls	50? "
Krameria	43 "
Catechu	40 "
Uva Ursi	36 "
Pomegranate-bark	19 "
Tormentil	18 "
Oak-bark	16 "

These numbers are a tolerably fair measure of the astringent power of the substances named. But it must not be supposed that the astringent principle is in all cases strictly identical with Tannic acid, properly so called; for there appear to be various modifications of this substance contained in the different plants, many of which have peculiar chemical characters of their own, but all of which agree in possessing the power of tanning, or combining with animal gelatine, and in the medicinal property of astringency.

SULPHATE OF MAGNESIA.

Class I. Div. II. Ord. I. Antiphlogistica.
Class IV. Ord. III. Cathartica.
Class IV. Ord. VI. Diuretica.

I have selected this salt as the subject of a brief history, both because its action may be taken as the type of that of soluble salines in general, and because I think we are in a condition to determine this operation with some precision.

It is a crystalline substance, very soluble in water, and not exhibiting active properties in a small dose. If given in the solid state, it is reduced to solution in the stomach. If given in solution, it is absorbed: immediately, if the solution be of low specific gravity; or, if dense, as soon as it has been properly diluted down by the gastric or intestinal secretions. We have proof that it always passes into the blood. When it acts as a diuretic, it is discovered in the urine, and must therefore have traversed the system. And the experiments given below afford proof that when it acts as a purgative, it disappears in the first instance from the intestinal canal, passing into the blood by absorption. As this is shown to take place with a dense solution, it must also occur with a weak one, as to the passage of the latter there is no physical obstacle in the endosmotic conditions.

The ultimate action of such a soluble saline is, as an eliminative, chiefly on the kidneys and intestines; but, before this, it has an action in the blood, which is of the antiphlogistic kind. These salts act as solvents of Fibrine in experiments made out of the body. Simon, Schultz, Golding Bird, and others, have demonstrated that by this chemical action they have the power of diminishing the amount of this Fibrine in the blood of the patient to whom they are administered. And Gulliver has found that their solutions antagonize the tendency of the red blood-corpuscles to aggregate in rows,—a tendency especially observed in the blood of inflammation. It is by such actions as these that the Sulphates of Soda and Magnesia, as well as all soluble salines, are of use in acute fevers and inflammations. They may exert over the development of plastic fibrine a controlling power which is not possessed by blood-letting, and they directly counteract an abnormal dynamic tendency. These sulphates are antiphlogistic purgatives; they are especially adapted for use in inflammatory and febrile disorders, for, before they operate on the bowels, they traverse the blood.

These salts act on the eliminative system as Cathartics and Diuretics; and though their determination to the bowels or the kidneys may be somewhat affected by the condition of the patient, it mainly depends on the amount of the dose. I have already taken pains to disprove a prevalent notion that the diuretic or cathartic action is a simple result of the comparative dilution or density of the aqueous solution of the salt; and have shown by experiments and otherwise, that a sufficient quantity of the salt will prove purgative, in whatever form it be given. (*Vide* Prop. II.) A smaller dose than this may be eliminated by the kidneys, which are unable to excrete a large quantity at a time. Such a small dose proves diuretic, and is discoverable in the urine by chemical tests. A larger dose is cathartic, and passes off with the fæces, where it has been detected by Buchheim.

But it may be said, and is still said by many, that this large dose is not absorbed at all; that it causes, by some topical action, a flow of serum into the intestine, and that it leaves the bowel along with the increased secretion, where its presence is easily accounted for by supposing that it never left the intestinal canal.

I think it may be affirmed that this is not a correct view of the case. I maintain that the saline first obeys the law of absorption, applicable to all materials which are in any way soluble in the upper part of the intestinal canal; that it passes from thence into the blood, circulating with it, and working upon it in the manner just narrated. But as it cannot remain there, it appears that it is subsequently excreted from the blood at the lower part of the intestinal canal, by that glandular mucous surface whose natural secretion it stimulates and augments. All this occupies but a few hours. I conceive that I am to a great extent justified in the above conclusions by the result of the following experiments, which were conducted with care, and were designed to test and illustrate the theory here stated.

If it be true that Sulphate of Magnesia, when given as a purgative, is first absorbed, and afterwards again excreted into the cavity of the bowel,—then, if we could examine the alimentary canal which had received the salt, we should find, at a certain period after the reception of the latter, that it had more or less completely disappeared by the process of absorption; and, at a certain later period, we should discover the same salt abundantly present in the cavity of the bowel, because now undergoing excretion from the blood. It is obviously impossible to make these observations on the same animal. The next best thing is to make use of animals in the same condition, and, as nearly as can be judged, of similar vital powers.

I therefore chose three dogs, all in a state of health, and of the same size and condition. I administered to each of them, at the same time, a solution consisting of 3 drachms of Sulphate of Magnesia dissolved in 3 ounces of water (having the specific gravity of 1·066.) It had previously been ascertained that this dose produced purging in another dog in about three hours. The times for killing each of the three dogs were chosen accordingly. They were not allowed to live long enough for the production of purging; neither was anything lost by vomiting, or by want of care in the administration of the solution, which was done through a syringe.

1. The first dog was killed after three-quarters of an hour. The intestines were comparatively empty. From the stomach, bowels, and their contents, the soluble matters were extracted by repeated washing, and long maceration in water. These washings were filtered through a cloth, and then evaporated to dryness. The residue was again treated with water, and a clear solution then obtained by infiltration. It was now precipitated by Phosphate of Soda and solution of Ammonia, the

precipitate washed with solution of Muriate of Ammonia, the Ammonio-phosphate of Magnesia dried, and ignited for some time in a platinum capsule. What remained was Phosphate of Magnesia. It was weighed, and the Magnesia calculated from it. Another simple calculation gave the amount of the crystalline Sulphate to which this corresponded. The result showed that only 55·928 grains of the salt remained in the intestinal canal out of the 180 grains administered.

2. The second dog was killed after one hour and a half. The stomach and intestines were at once removed, and the latter found rather full. They were subjected to the same chemical analysis. The result was that 77·354 grains of Sulphate of Magnesia were found in the intestinal canal.

3. The third dog was killed after two hours and a half. The bowels were found much distended. (This was shortly before the time at which purging had commenced in another animal.) The same process being followed, a quantity of Magnesia indicating 96·985 grains of the crystallized sulphate was discovered in the stomach and bowels.

From these experiments several things appear. The longer the time allowed after the administration of the dose, the larger the amount of salt discovered in the bowel. The shortest time left was three-quarters of an hour. About 55 grains was then all that was left of the 180 grains given, the rest of which must have been absorbed, as none could have been lost in any other way. Three-quarters of an hour further being allowed to the second dog, about 22 grains more are found in his intestines, which are more filled with fæces. From which I am led to suppose that the minimum of the salt to be found, or the maximum of absorption, in these animals, must have been between these two periods, or after about one hour. For at three-quarters of an hour it is undergoing rapid absorption, and at one hour and a half it is being again excreted into the intestine. Again, after another hour, the contents of the intestines are increased, and the amount of the salt has risen to 96·98 grains. Purging would soon follow, and the excretory process, having already expelled from the circulation more than half of the sulphate which had entered it, would go on until the whole had been cast out in the same way.

These experiments are perhaps as little liable to objection as any of the kind can be. They seem to confirm the law of the primary absorption, and subsequent excretion, of a purgative saline dose. Certain facts observed by others may be further alleged in confirmation. That the Sulphate of Magnesia will purge after it has passed into the blood, has been proved by Aubert, who found that its injection into the veins of a dog was followed by purging. That agents which retard excretion from the surface of the bowel will prevent the purging from taking place, appears from the experiments of Buchheim (*v.* p. 85,) who finds that combination with a sufficient dose of Morphia or Tannic acid will prevent the Sulphate of Magnesia or of Soda from proving purgative, or passing out by the bowels.

GENERAL INDEX.

THE END.